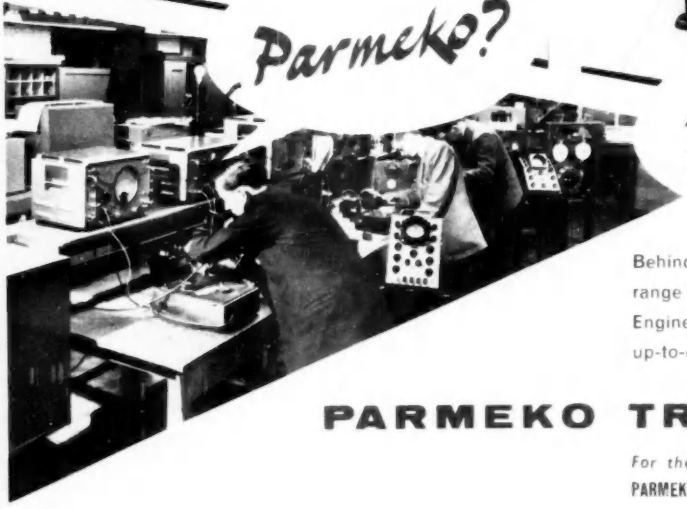
Electronic Engineering

Parmeko?

Precisely!



Behind the most comprehensive range of transformers available to the Electronics Engineer today lie Parmeko's most complete and up-to-date research and design facilities.

PARMEKO TRANSFORMERS

For the Electronic and Electrical Industries

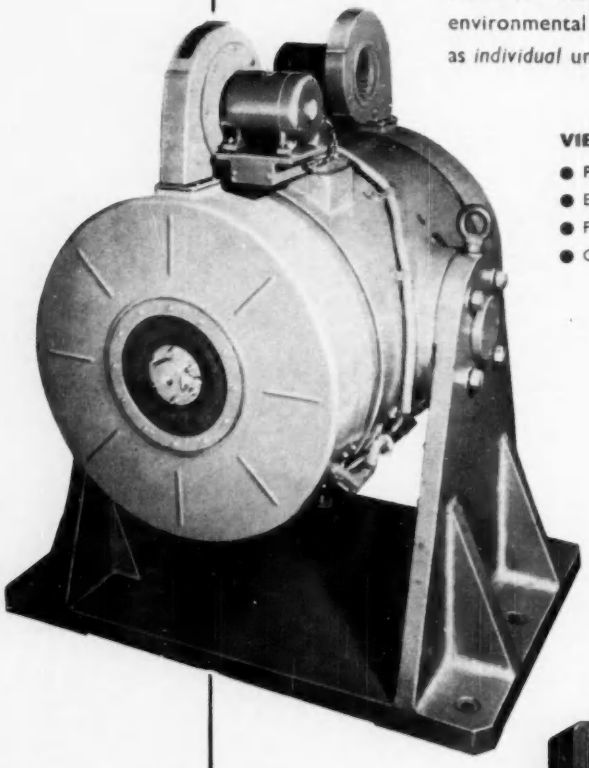
PARMEKO LIMITED, PERCY ROAD, LEICESTER.

THREE SHILLINGS

SOLVING VIBRATION PROBLEMS

with a complete vibrator installation by E.M.I.

Evolved after many years of experience in this field, E.M.I. Vibration Equipments are designed to meet a wide variety of requirements in fatigue and environmental testing. They are now available as *complete* installations or as *individual* units.



VIBRATOR MODEL EMV 3000

- Peak Thrust: 3000 lb.
- Excursion: 0.9" p - p.
- Frequency Range: 5 c/s — 1 Kc/s.
- Operational Position: 0°, 45° or 90°.

CONTROL DESK

Amplifier Remote Controls ● Swept Range Oscillator ● Two "g" measuring oscilloscope for six channel monitoring ● Autostrobe units for driving stroboscope to give:—

A Synchronous illumination.

B Synchronous illumination with up to 2 c/s slip.

C Synchronous illumination but variable phase, C-360 .

5kw AMPLIFIER

Fully Balanced and Stabilised

- Switched Impedance Matching
- Built-in Vibrator Field Supply
- Frequency Range 5 c/s - 5 Kc/s
- Total Distortion less than 2%.

Ancillary Equipment

HIGH POWER stroboscopes, accelerometers and cathode followers.

Other Vibrator Equipments:

EMV 1 and EMV 5.

If you have a vibration problem, our specialist staff will be pleased to advise you. For full details kindly telephone or write to:

E.M.I. ELECTRONICS LTD

INSTRUMENT DIVISION

HAYES · **MIDDLESEX** · Telephone: SOUthall 2468 Ext. 655 and 1071.

EE132

CLASSIFIED ADVERTISEMENTS

The charge for these advertisements is 6d. per word. Minimum charge 12/-. Box number 2/- extra, except in the case of advertisements for "Situations Wanted," when it is free. Specially spaced advertisements per inch single column 42/6. A remittance must accompany the advertisement. Replies to Box Numbers should be addressed to : "Electronic Engineering," 28, Essex Street, Strand, London, W.C.2. Advertisements must be received before the 14th of the month for insertion in the following issue

OFFICIAL APPOINTMENTS

APPLICATIONS ARE INVITED by the Commonwealth Relations Office for an appointment, under the Technical Co-operation Scheme of the Colombo Plan, as Professor of Communications Engineering at the Indian Institute of Technology, Kharagpur, India. Will be required to organise courses in Communications Engineering and to train the Institute's teachers and research workers in developing the laboratories and the general activities of the Department. Must be an engineer or scientist with special theoretical ability and should have made a contribution towards the development and application of communications engineering. Should have specialised in Communications Theory, Feedback Theory and Servo Control and/or Microwave Engineering. Duration, three years. Contract with the U.K. Government. Salary, £2,000 p.a. (subject to U.K. income tax) plus tax-free oversea allowance of £1,330 p.a. (married) or £750 p.a. (single), plus other allowances. Free furnished family accommodation provided. For further information and application forms write Ministry of Labour and National Service (E.9), 26-28 King Street, London, S.W., quoting A.12/IND/244/TCS. W 2718

COMMONWEALTH OF AUSTRALIA. Patent Office. Examiners of Patents. Applications are invited for permanent positions as Examiners of Patents, Grade 1 (£A1,043-£A1,493), in the Australian Patent Office to undertake the official scientific, technical and legal work in connexion with Patent Applications. Vacancies exist for Electronic (Computer, Television or Radar) Engineers or Scientists, Telephone Engineers, Organic Chemists and Mechanical Engineers. Applicants must have an appropriate Degree or diploma or have achieved a professional qualification, e.g. A.M.I.Mech.E., A.M.I.E.E. or A.R.I.C. Commencing salary will depend on qualifications and experience and will not exceed £A1,313 per annum. Advancement beyond £A1,313 is dependent upon passing prescribed Patent Law examinations. Further opportunities exist for promotion to Grade 2, Grade 3 and Supervising Examiner (£A1,993). All salaries are in Australian currency and will commence from the date of embarkation. All appointments are for Canberra. A limited number of new unfurnished houses are available on a rental basis for married appointees, and modern guest house accommodation will be provided for other successful applicants. Assisted passages can be arranged by the Commonwealth Immigration Authorities in London for successful applicants and, if married, their wives and dependent children. Application form and further particulars may be obtained from The Public Service Board Representative, Australia House, Strand, London, W.C.2. Early application is advised. W 2740

COMPUTER DEVELOPMENT. There are vacancies at the Atomic Energy Research Establishment, Harwell, in work on the development and engineering of computers and their application to engineering problems in the reactor field. A knowledge of computer techniques is essential and one post requires considerable experience in design of computer circuitry. Salary: up to £1,740 depending upon age, qualifications and experience. There are vacancies in the Engineer, Scientific and Experimental classes. Send Post Card to Recruitment Officer (1012Z/42, A.E.R.E., Didcot, Berks, for application form and details. W 2715

ENGINEER (BASIC GRADE) required by the Atomic Weapons Research Establishment, Aldermaston, Berks, to assist in a section dealing with the engineering design of electronic and electromechanical weapon equipment to meet Service requirements on the basis of information supplied by the research and development laboratories. To arrange for the issue of information to contractors and inspectorates and advise them in early stages of Production. A recognized engineering apprenticeship and A.M.I.Mech. or E.E. or equivalent qualifications required. Previous experience of this class of work desirable. Salary: £815 (at age 25) to £1,110 (at age 34 or over) to £1,270 p.a. Contributory Superannuation Scheme. A house or assistance towards legal expenses on house purchase will be available for married officers living beyond daily travelling distance. Postcards for application forms to the Senior Recruitment Officer at above address. Please quote ref. 1674/42. W 2729

BRISTOL EDUCATION COMMITTEE. College of Technology. Principal: G. H. Moore, M.Sc., F.P.S., F.R.I.C. Applications invited for post of Senior Lecturer in Department of Electrical Engineering. Candidates should hold Degree and have appropriate professional qualifications, with industrial and teaching experience; must be capable of teaching Electronics and Telecommunications for I.E.E. (Part III), B.Sc. (Eng.) Degree, and Dip. Tech. (Eng.). Salary in accordance Burnham Report (£1,350×£50 to £1,550). Application forms, returnable within two weeks of date of this advertisement, from Registrar, College of Technology, Ashley Down, Bristol 7. W 1964

ELECTRONICS TECHNICAL ASSISTANT required in Interdepartmental Workshop of Royal Free Hospital School of Medicine, 8 Hunter Street, London, W.C.1. Applicants should be capable of maintaining and servicing existing equipment and assisting with the design and production of new electronic apparatus such as biological amplifiers, pulse generators, oscilloscopes, etc., to be used for research work in the various departments of the medical school. The appointment offers scope to a person who has sufficient enthusiasm and ability to seek work of a non-routine nature. The minimum salary will be £760 p.a. depending upon the theoretical qualifications and practical experience of the applicant. Apply to Secretary at above address, with names of two referees. W 2702

MEDICAL RESEARCH COUNCIL—Junior Development Engineer required. A sound knowledge of electronics is essential and some experience of prototype work desirable. The salary will commence in the range £535-£715 depending upon qualifications and experience, rising by annual increments up to a possible maximum on the scale of £870. Write stating age and full details of education and experience to Personnel Officer, National Institute for Medical Research, The Ridgeway, Mill Hill, N.W.7. W 1947

POST OFFICE: ASSISTANT ENGINEER. At least ten posts for men aged at least 17½ and under 23½ on 1st March, 1958, with extension for service in H.M. Forces or H.M. Overseas Civil Service and, up to two years, for established civil service. Written examination, beginning 15th April, 1958, in English, Physics and two prescribed optional subjects, followed by interview of qualified candidates. Starting salary (London) £490 at 18, 19 or 20, £540 at 21, £685 at 25 or over, rising to £1,000. Particulars and application form from Secretary, Civil Service Commission, Burlington Gardens, London, W.1 (postcards, quoting 159/58). Application forms should be returned by 6th February, 1958. W 2742

RESEARCH ASSISTANT for Electronic work in connexion with machine and power system analysis and operation, including development of analogue computers and other devices. Applicant must have sound theoretical training of Honours Degree standard and possess initiative. Salary up to £1,000 p.a. according to qualifications. Apply to Department of Electrical Engineering, Imperial College, London, S.W.7, before 11 February. W 2736

SENIOR TECHNICIAN or TECHNICIAN required in the Physics Department for electronics work in connexion with a 30meV synchroton and other projects. Candidates should preferably possess Higher National Certificate or equivalent qualification. Salary according to qualifications and experience—Senior Technician £620 × 20-660 × 25-£760 plus London Weighting; Technician £515 × 20-555 × 25-£630 plus London Weighting. Applications, giving names and addresses of three referees should be sent as soon as possible to the Secretary, Institute of Cancer Research, Royal Cancer Hospital, Fulham Road, S.W.3. W 2703

SENIOR & JUNIOR ENGINEERS. The Research and Development section of a long established manufacturer situated in N.W. London, has vacancies for Senior and Junior Engineers. A specialised knowledge and experience of instruments, energy metering, electronics or electromechanical devices would be advantageous. Educational qualifications required are Science or Engineering Degree or H.N.C. with endorsements for the Senior positions or at least O.N.C. level for Juniors. The salaries offered are £800 upward for Seniors and £500-£750 for Juniors according to experience. A Staff Pension Scheme is in operation and working conditions are excellent. Write, giving full particulars and present salary to Box "A.K.", c/o J. W. Vickers & Co. Ltd., 7/8 Great Winchester Street, E.C.2. W 2727

MIDDLESEX COUNTY COUNCIL, Education Committee, Brunel College of Technology, Woodlands Avenue, Acton, W.3. Applications are invited for the post of:—Lecturer in Electronics to teach the subject in courses leading to B.Sc. (Eng.), and Dip. Tech. (Eng.). Candidates should be well qualified and be Corporate Members of the Institution of Electrical Engineers, and have teaching as well as industrial and/or research experience. Opportunities given to take part in the development of research projects. Salary in accordance with the Burnham (Technical) Report 1956, i.e. £1,200 × £30 — £1,350 plus London allowance. Application forms and further particulars (stamped addressed foolscap envelope) from the Principal to whom completed forms should be returned within 14 days of the appearance of this advertisement. C. E. Gurr, M.Sc., Ph.D., Secretary to the Education Committee. W 2725

STUDENT APPRENTICESHIPS IN ATOMIC ENERGY. The United Kingdom Atomic Energy Authority has vacancies for Student Apprentices to begin training in September 1958. Apprenticeships will be awarded in Electrical, Electronic, Mechanical, Chemical and Physics, Engineering and Metallurgy. Duration: Five Years, with extension if necessary to complete an approved course of study. Practical Training: This will be given at one of the following establishments: Atomic Energy Research Establishment, Harwell, Berks, and Winfrith Heath, Dorset; Atomic Weapons Research Establishment, Aldermaston, Berks, Industrial Group Works in Lancashire, Cheshire and Cumberland. Theoretical Training: Facilities for study include (a) Day release, (b) Sandwich, or (c) Full-time University Courses. Age Limit: Applicants must be under 18½ on September 1, 1958. Minimum Entry Qualifications: Either (1) G.C.E. in 5 subjects to include the following: "O" level in English Language; "A" level in two of the following subjects: Maths. (or Applied Maths.); Physics; Physics with Chemistry. Or (2) S2 National Certificate in Engineering at age 17½; S3 National Certificate in Engineering at age 18½. A medical examination will be required. Application forms and further information from the Chief Labour Officer, United Kingdom Atomic Energy Authority, Bedford Chambers, Covent Garden, London, W.C.2. Closing date 28 February, 1958. W 2732

THE MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY (Faculty of Technology in the University of Manchester). Graduates with an interest in Electronics are invited to apply for the post of Lecturer in the Department of Textile Industries with the title and status of Lecturer in the University of Manchester. The salary will be on the scale £900-£1,650, according to qualifications, with superannuation under the F.S.S.U., and family allowances. The Department has excellent research facilities and members of the staff are expected to undertake and supervise research. University regulations permit teaching staff to read for the degrees of M.Sc.Tech., and Ph.D. A knowledge of experimental stress analysis is desirable, textile experience is not essential. Conditions of appointment and an application form may be obtained from: The Registrar, The Manchester College of Science and Technology, Manchester 1. The last day for the receipt of applications is March 1st, 1958. Applications by airmail (no forms) will be considered from overseas candidates. B. V. Bowden, Principal of the College. W 2710

THE NATIONAL RESEARCH COUNCIL OF CANADA, Ottawa, Ontario, requires Scientific Staff. Applications are invited for vacancies in the Instruments and Control Systems Laboratory of the Division of Mechanical Engineering. Duties will include development of special instrumentation equipment and systems for laboratory, field and airborne use. Design and development of automatic control systems. Applicants must be graduates or post graduates in Engineering Physics, Electrical Engineering or Mathematics and Physics from a university of recognized standing. Experience in the fields of instrumentation, industrial electronics, computer design, precision gyroscopes or magnetic recording techniques would be an advantage. Starting salary up to a maximum of $8,700 per annum will depend on the qualifications of the successful applicant. Employee benefits include a five-day week, generous provision for vacation and sick leave, medical-hospital insurance plans and an attractive pension scheme. Applications should be directed to the Employment Officer, National Research Council, Sussex Drive, Ottawa 2, Canada. Please quote file ME-497. W 1937

OFFICIAL APPOINTMENTS (Cont'd.)

UNIVERSITY OF EDINBURGH. Applications are invited for I.C.I. Research Fellowships in Biochemistry, Chemistry, Engineering, Pharmacology, Physics, Chemical Technology, or Chemical Engineering, to which some appointments will date from 1st October, 1958 (or earlier in the case of selected candidates who may be available before that date). The salary will depend upon qualifications and experience, but will normally be within the range of £800 to £1,000 per annum, together with F.S.S.U. benefits and family allowance. Forms of application and further particulars may be obtained from the undersigned. Applications (two copies) should be submitted not later than 15th February, 1958. Charles H. Stewart, Secretary to the University. W 2716

SITUATIONS VACANT

AN ELECTRONIC ENGINEER required by well-known instrument Company in London. B.Sc. in Electrical Engineering essential. Age 22-28; to work on transistor circuit development, for very interesting industrial applications. Salary £750-£850. Write Box W 1936.

A LONG ESTABLISHED and important manufacturer of industrial instruments (electrical, electronic, pneumatic and hydraulic) in the South London area, wishes to engage a development engineer with experience of, and most certainly a wide interest in circuit development. The work would be applied to novel and most interesting projects in the optical, ultrasonic and other fields allied and useful to the industrial instrumentation field. There would be ample opportunity for creative thought and the pursuit of original ideas in carrying out projects. A keen, inventive mind, able to absorb new techniques and apply his present knowledge is more important than possessing a 1st Class Degree, though we anticipate that the possession of some senior professional qualifications will be necessary. Commencing salary we envisage is about £1,100 per annum, but persons applying should state all relevant details and send applications to CDE/D, Box W 1949.

ASSISTANT CHIEF ENGINEERS with prospects of early promotion to Chief Engineers required for modern Laboratory of a progressive engineering company situated in the Eastern suburbs of London. The selected candidates will be responsible for the control of design and engineering aspects of the manufacture of products in the following fields: T.V. component design and circuit application work, or R.F./I.F. & Tuner Applications in Radio & T.V. Fields. These vacancies are caused by normal expansion of company business and present excellent opportunities. A good and progressive salary, commensurate with qualifications and experience, will be paid to the successful applicants. Please reply, giving full details to Box W.2707.

AUTOMATIC CONTROL. A vacancy exists in the recently formed Automatic Control Section of the Research and Development Department of The United Steel Companies Ltd. Qualifications: a good degree or equivalent in Engineering or Applied Science. Previous experience preferable but personal initiative, engineering and technical ability coupled with enthusiasm are highly important. Salary £700-£1,100 according to experience. Applications to the Secretary, Swinden Laboratories, Moorgate, Rotherham. W 2722

CIRCUIT DEVELOPMENT ENGINEER, Domestic Radio and Television. Apply giving details of experience, qualifications and salary required to Chief Engineer, Raymond Electric Ltd., Brent Crescent, London, N.W.10. Tel. ELGar 6687. W 1959

DEVELOPMENT ENGINEER for Research Department developing electronic and light electromechanical control equipment. Applicants should possess H.N.C. or equivalent qualifications and have at least three years' experience in similar work. Salary according to experience. Londex Ltd., 207 Anerley Road, London, S.E.20. Phone SYD 3111, Ext. 17. W 1954

BRITISH TELECOMMUNICATIONS RESEARCH LTD. have vacancies for: (a) An Engineer to develop and design small transformers and inductors for use in communications systems. Previous experience in this field is desirable and preference will be given to a candidate with experience of Ferrite application. (b) An Engineer to develop an interesting project with world-wide application and involving the use of transistors and printed-circuit techniques in miniature R.F. equipment. Candidates should preferably be graduates or equivalent and have some experience in this field. Both positions offer stimulating opportunities for new development work with attractive salaries and first-rate social amenities. The positions are permanent, include participation in the Company's Superannuation Scheme, and assistance with housing can be arranged. The Laboratories are situated in ideal surroundings adjoining some of the finest reaches of the Thames, and yet within an hour of London. Saturday morning interviews can be arranged. Applications should be addressed to The General Manager, British Telecommunications Research Ltd., Taplow Court, Taplow, near Maidenhead, Berks. W 1960

BRUSH ELECTRICAL ENGINEERING CO. LTD., Loughborough, has a vacancy for a Senior Engineer to undertake research work in advanced digital computer and digital control technique. Practical experience of the work is essential and the position offers opportunities for development in a wide field. Experience in transistor circuitry would be an advantage while good theoretical qualifications are essential. A good salary will be paid to the successful applicant who will be employed in our new Research Laboratories where working conditions are excellent. The Laboratory is situated in a pleasant Midland town within easy reach of a number of cities. Conditions of service include a generous non-contributory Staff Assurance Scheme. Please apply to the Chief Personnel Officer, Loughborough, Leics, quoting Reference R7323. W 2700

DESIGN ENGINEER REQUIRED for orginal development and design work on Power Magnetic/Amplifiers and Transformers. H.N.C. or equivalent coupled with design experience in this field. Factory situate in Crawley New Town, Sussex. Housing accommodation is available and there is a pension scheme if desired. Apply in writing to: Hirst Electronic Ltd., Gatwick Road, Crawley, Sussex. W 1952

DESIGNER, experienced in design and manufacture of transformers between fractional V.A. and 250 K.V.A. Designs for particular applications a speciality. Knowledge of chokes and rectifiers an advantage. Send summary of experience and qualifications, stating age and salary required to Manager, Transformer Department, Austin Walters & Son Ltd., Ayres Road, Old Trafford, Manchester, 16. W 1967

ELECTRICAL DEVELOPMENT ENGINEERS (Grad.I.E.E. or equivalent) required for interesting work on advanced electromechanical systems. Familiarity with basic servomechanism theory and practice, an advantage. Electrical Draughtsman (O.N.C. or equivalent) required to work with development team on preparation of schematic and other diagrams. Successful applicants will work from the design office but will follow work through from laboratory to field trials. Posts are permanent and include participation in voluntary superannuation scheme. Write with details of age, qualifications, experience and salary required to Chief Electrical Engineer, British Manufacture and Research Co. Ltd., Grantham, Lincs, quoting Ref. AWK/MF/EE. W 337

DEVELOPMENT ENGINEERS REQUIRED for the Laboratory of a large Engineering Company dealing with the advanced design and development of Vibrators and Relays and Light Electro-Mechanical equipment. To applicants with experience in this field these vacancies offer an excellent salary and good prospects of future advancement. London area. Minimum qualification O.N.C. Please reply, giving full details of qualifications and experience to Box W 2723.

DEVELOPMENT ENGINEERS (SENIOR) required for a design group concerned with a wide range of Small Transformers of the types used in receiver equipment and electrical appliances; T.V. component design and circuit application work; R.F./I.F. and tuner applications in radio and T.V. fields. An attractive salary is offered together with good future prospects. The Company's extensive laboratory and production facilities are situated in the eastern suburbs of London. Please reply, giving full details of qualifications and experience to Box W2724.

DRAUGHTSMAN—ELECTRONIC. Opportunity for first-class man as leader in small development drawing office situated near Southampton. Must be experienced on mechanical design of equipment for Service use. Housing assistance given. Write full details, Box W 2733.

ELECTRICAL ENGINEERS OR PHYSICISTS, required for work on a special project, involving the development of a modern, complex, microwave electronic valve. Minimum qualification O.N.C. or Inter B.Sc. Previous experience in this field is not essential. The vacancies give opportunities for candidates to become experienced in advanced microwave techniques. Apply, quoting M/1 to Personnel Officer, M.O. Valve Co., Hammersmith, W.6. A subsidiary of The General Electric Company. W 2706

ELECTRONIC DEVELOPMENT ENGINEERS. A Midlands Manufacturer has vacancies for First-Class Development Engineers for work on domestic Television. Experience is preferred and minimum qualification is H.N.C. Those interested should write giving a full account of experience and qualifications to the Personnel Manager (Ref. EDE). Box W 2738.

ELECTRONIC ENGINEER REQUIRED to work on a wide variety of measuring instruments and similar equipment. Ample scope for ideas and initiative coupled with the ability to "get things done." Substantial prospects for advancement in rapidly expanding company. Rivlin Instruments Ltd., Doman Road, Yorktown Industrial Estate, Camberley, Surrey. Telephone: Camberley 2507/8. W 1956

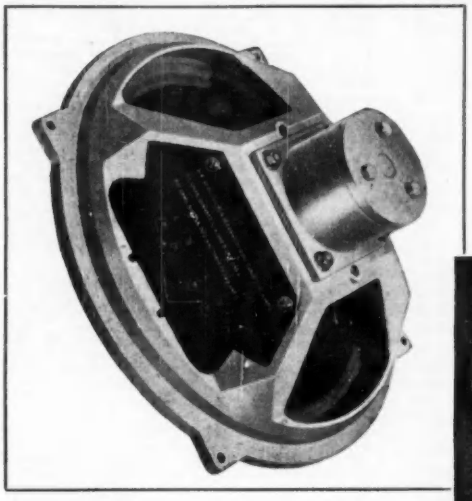
ELECTRONIC ENGINEER REQUIRED to design and maintain electronic plant in an electrical instrument laboratory. The position requires first-class experience and practice in electronic engineering. The Company has a modern contributory pension scheme. 5-day week. Canteen facilities. Please send full details of age, experience and salary desired to Box W 1950.

ENGINEER to undertake design and test of high-grade sound and data recording equipment. Salary £1,050-£1,400. Excellent prospects with expanding concern. Write stating age, qualifications and experience to Leevers-Rich Equipment Ltd., 78B Hampstead Road, London, N.W.1. W 1951

ENGINEER REQUIRED for giving Technical Instructions, after a training period, on the maintenance of a complex Radar System. Practical experience and a sound understanding of modern Radar techniques necessary. Also a vacancy exists for a young Technical Assistant for training as maintenance engineer on a Digital Computer. Applications for these posts should be addressed to Construction Department, The British Thomson-Houston Co. Ltd., Rugby. W 2726

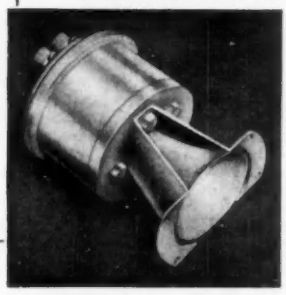
CLASSIFIED ADVERTISEMENTS
continued on page 4

THE FINEST TWO-SPEAKER SYSTEM WITHIN EVERYONE'S REACH



Thousands of Hi-Fi fans in all parts of the world have taken the trouble to write and tell us that—at just over £9—this two-speaker system is outstanding value. This is made possible only by more than thirty years' experience in sound reproduction combined with modern research and production methods in a self-contained organisation where even the smallest component is made to measure.

When housed in the cabinet described below, it forms a High Fidelity system of which anyone would be proud, both as regards its life-like reproduction and its distinguished appearance. We shall be pleased to send you fully descriptive leaflets and name of nearest stockist.



MODEL H.F.1012 10" Die-cast unit, 12,000 gauss magnet. Fitted with cambric cone, and universal impedance speech coil providing instantaneous matching at 3, 7.5 and 15 ohms. Handling capacity, 10 watts. Frequency response, 30 c.p.s.-14,000 c.p.s. Bass resonance, 35 c.p.s. (inc. P.T.) **£4.19.9**

T.10 TWEETER UNIT Moving coil pressure type. Speech coil impedance, 15 ohms. Response, 2,000/14,000 c.p.s. Flux density, 14,000 gauss. Handling capacity, 5 watts. Disperson angle, 90°. (inc. P.T.) **£4.4.0**

If required a suitable cross-over network is available at 30/-

"Prelude" Bass Reflex Console Cabinet One of our new series of contemporary cabinets in satin-striped sapele veneers. Supplied in ready-to-assemble form and put together in a few minutes with a screwdriver. Provides absolute realism in reproduction when used with Stentorian 8" or 10" units, provision for Tweeter unit. Size: 33" x 19" x 19½". **£11.11.0**

Stentorian

HIGH FIDELITY AT REALISTIC COST

★ *See and hear all W.B. products at our London office (109 Kingsway, W.C.2) any Saturday between 9 a.m. and 12 noon.*

WHITELEY ELECTRICAL RADIO CO. LTD · MANSFIELD · NOTTS

W B

THE LARGE RANGE of FINE QUALITY

Alma

PRECISION WIREWOUND RESISTORS

A.I.D. & A.R.B. Approved

All Alma precision wirewound resistors are designed and manufactured with great care to meet exacting requirements under rigorous conditions. Improved stability is obtained and the temperature coefficient is guaranteed. Special resistors can be supplied to customers' own specifications. Please write for further details of our specialised service

Alma **COMPONENTS Ltd.**

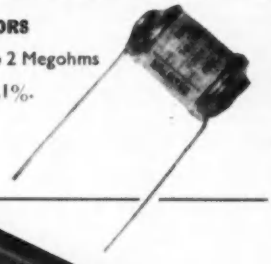
551 HOLLOWAY ROAD, LONDON, N.19

Telephone: ARCHWAY 0014/5

STANDARD TYPE RESISTORS

Resistance range 0.1 ohms to 2 Megohms to tolerances as close as ±0.1%.

Power ratings 1 Watt, ½ Watt and ¼ Watt.

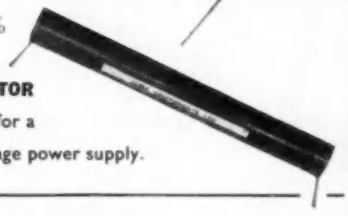


A 24 MEGOHM 1%

12 KV HIGH

STABILITY RESISTOR

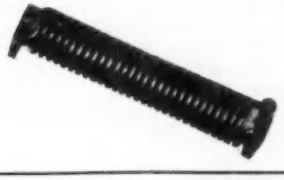
8½" x 1" diameter for a stabilised high voltage power supply.



A 0.1 ohm ±1%

40 WATT RESISTOR

7" x 1½" diameter stable meter shunt.



A "PLUG-IN" TYPE RESISTOR

A recently introduced range for use where flexibility combined with high performance is required.

ERICSSON TELEPHONES LTD. have in their Research Laboratories a number of vacancies for circuit designers and equipment engineers to work on nucleonic instruments, and interesting new developments in electronic computing and switching; both senior and junior posts are available. Applicants should have a degree or equivalent plus several years' experience of appropriate work for the senior posts; correspondingly reduced qualifications and experience will be accepted for junior posts. Salaries will be in accordance with age, qualifications and experience. Applications, giving details of age, academic or other training and qualifications, experience and starting salary required, should be sent to the Personnel Officer, Ericsson Telephones Ltd., Beeston, Nottingham. W 197

ERICSSON TELEPHONES LIMITED, Instrument Division, have vacancies for Senior and Assistant Electronic Engineers, Mechanical Design Engineers and Laboratory Assistants for interesting work on Industrial and Nucleonic Instruments. Attractive starting salaries and good prospects for advancement will be offered to successful applicants. Write to the Personnel Officer, Ericsson Telephones Limited, Beeston, Nottingham. W 333

EXPERIENCED TRANSFORMER DESIGN ENGINEER required for interesting range of problems including Magnetic Amplifiers and Pulse Transformers. A Degree or Higher National Certificate together with some experience in the above fields is preferable. Apply to: Personnel Officer, Cossor Radar & Electronics Ltd., 22 Highbury Grove, N.5. W 2705

EXTREMELY DIFFICULT PROBLEMS. Hard and concentrated work. The need for a continuous flow of bright ideas in the research and development of revolutionary electronic equipment. Compensated by high salary. A senior Electronic Engineer and an Assistant Electronic Engineer wanted to join a rapidly expanding company with world sales of electronic equipment. Qualifications for Senior Engineer. Degree, Grad.I.E.E. or H.N.C. For Assistant Engineer, good practical experience and some theoretical knowledge required. Applications will be treated as confidential and should be made to Research Department, J. F. Crosfield Ltd., 232 Old Street, London, E.C.1. W 1948

FERGUSON RADIO CORPORATION LTD. require Development and Maintenance Engineers for Television Test Gear Laboratory as follows: (1) Development Engineers with not less than three years' experience in this class of work. (2) Maintenance Engineers, preferably with similar Test Gear experience but receiver service engineers considered. Apply to: Personnel Manager, Ferguson Radio Corporation Ltd., Great Cambridge Road, Enfield. W 2737

OVERSEAS. Oil Exploration Company with world-wide seismic parties offers permanent career to electronic technicians. Maintaining and operating field equipment. Men prepared to accept responsibility and to live in camp conditions. Academic qualifications to H.N.C. or equivalent or genuine practical experience to this standard. Liberal home leave. Box W 336.

I.B.M. MACHINE ROOM SUPERVISOR, male, 28/40, required for new electronic computer installation. Must have good mathematical knowledge to minimum H.N.C., or equivalent standard and preferably had experience as assistant with I.B.M. or B.T.M. installation. Will be required to attend manufacturers courses. Apply in writing giving full details and some indication of salary required (in confidence) to the Secretary, Belling & Lee Limited, Great Cambridge Road, Enfield, Middlesex. W 2730

LEO COMPUTERS LIMITED. Senior Development Engineers and Physicists. LEO Computers Limited invite applications from senior engineers and physicists interested in all aspects of computer development. All applicants will be considered on their merits, but a 1st or 2nd class Honours Degree in physics or electrical engineering will be a definite advantage. Only those having definite inventive and logical faculties coupled with practical experience of electronic research or development will be suitable for these posts, which involve the formulation of development plans and direction of junior staff. For men with initiative and judgment there are excellent prospects in this expanding company. The positions are permanent and pensionable and starting salaries will depend on previous experience. Applications, which will be treated with strict confidence, should give details of qualifications and experience and should be addressed to: Personnel Officer, LEO Computers Limited, Minerva Road, Park Royal, London, N.W.10. W 2744

METROPOLITAN-VICKERS ELECTRICAL COMPANY LTD. Development Engineers for Electronics Department. Graduate Engineers or Physicists with two or more years' experience in the field of microwave techniques or microwave receiver systems are required for theoretical or practical work in the development laboratories of the Radar Division. Applicants are requested to write, quoting reference F.10 to: Personnel Manager, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17. W 2669

MUIRHEAD & CO. LTD., Beckenham, Kent, require Electronic Test Engineers for modification, test and calibration of the Company's range of instruments covering the lower frequency range of 0·1c/s 100Kc/s. Some technical qualifications an advantage but real technical experience with high grade equipment is the first requirement. Each Engineer is responsible for his individual job, from the initial fault finding to the finished job ready for inspection. These are staff appointments with ideal working conditions. Salaries commensurate with qualifications and experience. A Pension Scheme is in operation and the Company has its own Sports Ground. Please write giving full particulars to the Personnel Manager. W 2720

REGUNNING TECHNICIAN REQUIRED. Knowledge of heater and cathode coating techniques. Salary according to ability but not less than £1,000. ROD 6672 up to 11 p.m. W 1962

SALES ENGINEER required with connexions in the Electrical and Electronics Industry, for Sales Office engaged in the marketing of Relays and similar Electro-Mechanical devices. Duties will consist of evaluating customers' requirements by correspondence and by personal contact. Applicants should possess H.N.C. or equivalent and have had previous sales experience. Pension and Bonus Scheme after qualifying period. Write giving full details of experience, age, etc., to Personnel Manager, Telephone Manufacturing Co. Ltd., Martell Road, West Dulwich, S.E.21. W 2746

RADIO/ELECTRONIC ENGINEER. Opportunity for Degree standard engineer for long term VHF/UHF development work on Service equipment, in small organisation near Southampton. Housing assistance given. Write full details, Box W 2734.

PHYSICISTS AND ELECTRONIC ENGINEERS. Applications are invited for the following interesting and progressive posts: (a) Servo Engineer—to work on the analysis and synthesis of servos connected with a missile guided system. Experience in servo-theory is essential. (b) Systems Engineer—for the design and development of missile guided systems. (c) Electronic Engineer for design and development work on missile fire control systems. An interest in pulse circuitry and transistor techniques is desirable. For the above posts a Degree, or equivalent is required, with a minimum of two years' experience in industry. Applicants should be capable of taking some technical responsibility, and controlling the activities of one or two assistants. Starting salary would depend upon qualifications and experience. Further progress in salary and status would be determined by ability to take responsibility. Applicants should write to The Personnel Manager, Ref. 149B, de Havilland Propellers Limited, Hatfield, Herts. W 2717

PRODUCTION SUPERVISOR/ENGINEER required for small unit making high Quality and Precision Wirewound Resistors. Experience in similar field desirable but not essential. Must be production minded with drive and initiative to meet the needs of an ambitious expansion programme. Rivlin Instruments Ltd., Doman Road, Yorktown Industrial Estate, Camberley, Surrey. Telephone: Camberley 2507/8. W 1957

RADIO DEVELOPMENT ENGINEERS required for Senior and Junior positions. C. & G.I. Telecommunications or other recognised qualifications essential. Vacancies offer opportunity to work on interesting projects in well equipped, modern laboratory, and are permanent and progressive. Apply in writing in first instance to: Employment Officer, The Ever Ready Co. (GB) Ltd., Radio Department, Park Lane, Wolverhampton. W 2711

SEISMOGRAPH SERVICES LTD. of Holwood, Keston, near Bromley, require an engineer for testing electronic equipment used in geophysical prospecting for oil. Strong electronic background rather than academic qualifications. Experience audio amplifiers, magnetic and galvanometer recorders an advantage. Write full details and salary required, quoting TJA. W 2741

SENIOR ELECTRONICS ENGINEERS with experience and technical ability. Apply the Research & Development Organisation of A.G.I. Ltd., 105 Landsdowne Road, Croydon. W 2719

SENIOR PLANNING ENGINEER. A vacancy exists for a Senior Planning Engineer to provide the technical liaison between programme planning and engineering facilities. Applicants must have had considerable experience in all branches of Television production engineering, and be able to give rapid and accurate answers to Senior Programme Executives on Production requirements. Applications should be in by 1st March, 1958, and should be sent to A.G.M. (Staff), Associated-Rediffusion, Television House, Kingsway, London, W.C.2. W 2714

SENIOR SALES ENGINEER required by a Company situated in the N.W. Kent area. This is a new appointment which offers the prospects of promotion to deputy Sales Manager to a man who is suitably qualified and possesses drive and initiative. This appointment has become necessary to keep pace with the Company's expanding activities in the field of capacitors. It is essential that applicants should have a sound technical background in the power, radio or telecommunication field with preferably some experience in the sale of a wide variety of capacitors. A four figure salary, graded in accordance with experience, will be paid to the selected applicant with whom satisfactory arrangements will be made in connexion with travelling and expenses. Replies, which will be treated as confidential, giving full details of age, education, qualifications, positions held and the relevant salaries, should be sent to Box 3R K4109 A.K. Advg., 212a Shaftesbury Avenue, London, W.C.2. W 2708

TELECOMMUNICATIONS ENGINEER. Required by British Company in Bangkok a qualified engineer, age indication 25/30 years, preferably single, with at least 5 years' experience in the sales, installation and maintenance of telephone, radio and telegraph communications and knowledge of electrical equipment up to 3.3kV. Applicants should have had experience with a manufacturer of one of the required fields and preferably have served with an operating company or the signalling branch of H.M. Forces. Must be prepared to travel extensively. Write with full particulars to Box DE/102 c/o 95 Bishopsgate, London, E.C.2. W 2709

CLASSIFIED ADVERTISEMENTS
continued on page 6

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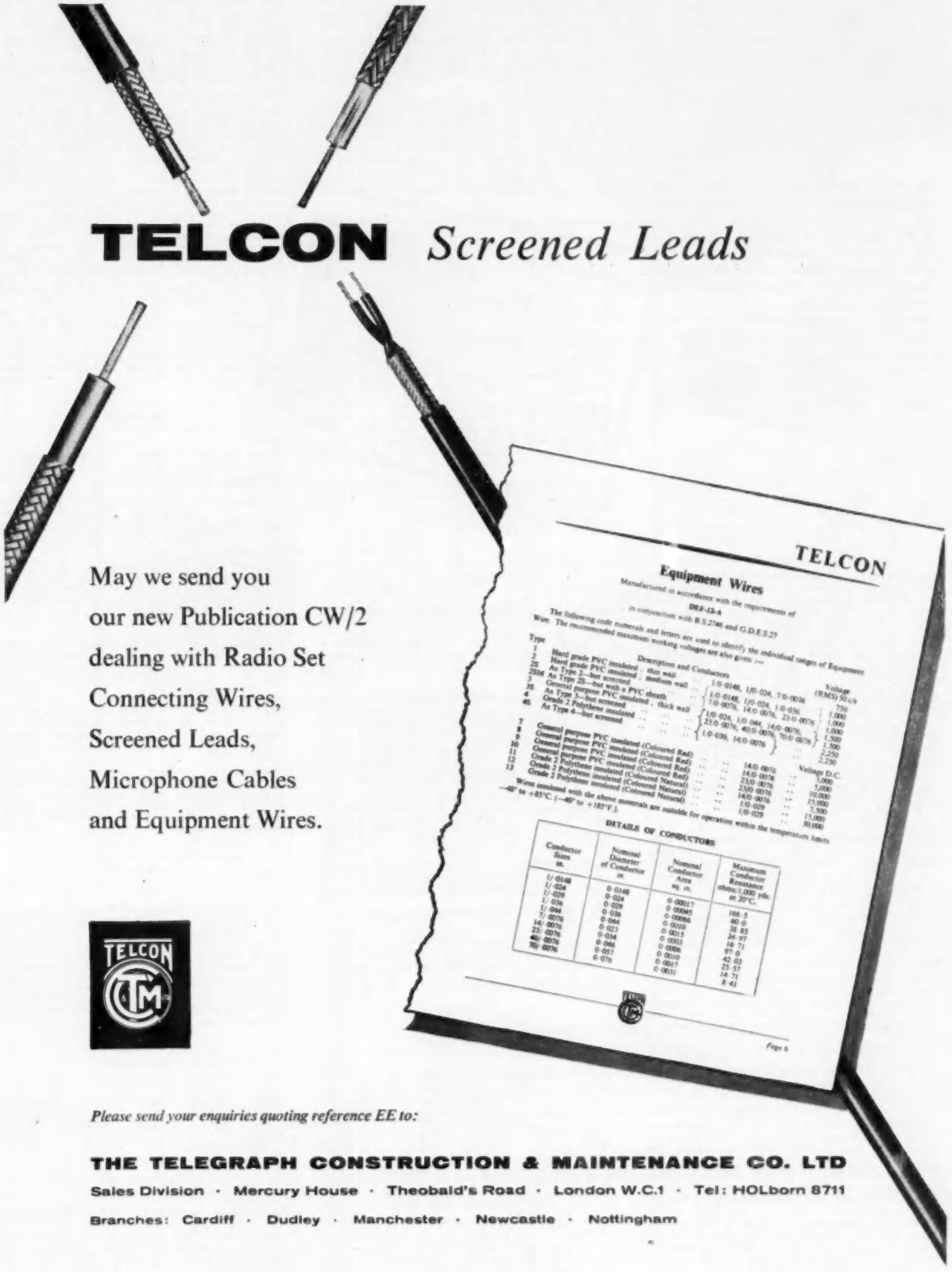

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dealing with Radio Set
Connecting Wires,
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Microphone Cables
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TELCON

Please send your enquiries quoting reference EE to:

THE TELEGRAPH CONSTRUCTION & MAINTENANCE CO. LTD

Sales Division · Mercury House · Theobald's Road · London W.C.1 · Tel: HOLborn 8711

Branches: Cardiff · Dudley · Manchester · Newcastle · Nottingham

SIR W. G. ARMSTRONG WHITWORTH AIRCRAFT LIMITED require Technical Representatives. These positions entail liaison work in the Service Department between the Company and the Admiralty in connexion with the Seaslug development programme. Applicants must have H.N.C. Electronics or equivalent, with a mechanical background. Attractive salaries are offered together with an excellent pension scheme. All applications will be treated in the strictest confidence, and should be addressed in the first instance to the Labour Manager, Sir W. G. Armstrong Whitworth Aircraft Ltd., Baginton, Nr. Coventry, Warwickshire. W 2712

TELEVISION DEVELOPMENT ENGINEERS. Two senior Engineers are required for the Development Laboratory of an important Company in a West London district. Applicants should hold good academic qualifications and have several years' experience in the development of black and white receivers and some knowledge of colour television. The positions are permanent and pensionable and offer scope for advancement. All applications will be treated in strict confidence and should give full details of experience, qualifications, age, and salary desired to Box W 2592.

TELEVISION TRANSMISSION EQUIPMENT. Senior Development Engineers required to augment a team engaged on Television cameras and allied equipment. Good salary. Superannuation Scheme, pleasant working conditions, Canteen, Sports and Social Club. Apply Chief Engineer, Peto Scott Electrical Instruments Ltd., Addlestone Road, Weybridge, Surrey. W 2735

TEST ENGINEERS required for interesting work in connexion with Radar, Computers, Machine Tool Control Units, Camera Channels, Microwave Links and similar electronic equipment. Applicants must have sound theoretical knowledge of electronics backed by practical experience in H.M. Forces or Industry. Staff positions and Superannuation Scheme. Single accommodation available. Apply, giving full details to Personnel Department (C.E./21), E.M.I. Ltd., Hayes, Middlesex. W 2731

THE GENERAL ELECTRIC CO. LTD., Radio and Television Works, Spon Street, Coventry. Requires Senior and Junior Electronic Development Engineers. Applicants for these posts should have experience of Military Electronic Equipment and preference will be given to those with qualifications in Electrical Engineering. Those interested in these posts are invited to write in confidence to the Personnel Manager. W 2701

TRANSISTOR and Printed Circuit Components. Radio Components: The Rapid development of Transistors and Printed Circuit techniques has given rise to an interesting field for design and application of new components for these fields. Permanent, pensionable posts are offered to Development Engineers wishing to undertake advanced development work of this kind. The Company's laboratories, situated in the London area, are fully equipped and offer agreeable working conditions. Write giving details of age, experience and qualifications, which will be regarded as strictly confidential to Box W 2721.

VALVE ENGINEERS & TECHNICIANS. Vacancies exist in a Research Laboratory for Engineers and Technicians with a good basic knowledge of valve techniques for work on special vacuum devices and microwave valves. Salaries are commensurate with experience and qualifications: the work is in an expanding group with a highly successful record. Apply Personnel Manager (Ref. 447), Elliott Brothers (London) Limited, Borehamwood, Herts. W 2704

WORKS TECHNICAL ENGINEER required by Furzehill Laboratories Ltd. for liaison duties between design and production departments. Experience is required both of electronic instrument design and of production test methods. This is a senior post with commensurate salary. Apply giving details of experience and salary required to Works Director, Furzehill Laboratories Ltd., Boreham Wood, Herts. W 2713

SITUATIONS VACANT Continued on p. 8

SITUATIONS WANTED

COMPANY DIRECTOR, with wide experience in the Electronics Industry, including Company Management, Design, Production and Sales, seeks interesting change at home or abroad. Management or Sales. Write Box W 1953.

EDUCATED, presentable young man, 27, sound knowledge and experience electronics, seeks opening where broad education, enterprising outlook and integrity are more important than technical ability. Anything considered, preferably with good-class embryonic concern. Box W 1955.

PACKAGING. Senior post required. Specialist in research and design for cost reduction. Present Electronics, medium-light engineering. Experienced D.E.F. 1234 Specifications, Admiralty, M.O.S., A.M. Box W 1965.

SERVICE

ASSEMBLY AND WINDING CAPACITY Electronic Equipment Supervised by technicians experienced in modern technique applicable to computers. V.H.F. and high-voltage oscillatory circuits. D.T.V. Contracts Dept. 138 Lewisham Way, New Cross, S.E.14. TIDeway 6666. Ext. 1. W 1758

CABLE-FORMS by Broxlea Products. See page 182 for details of a reliable and comprehensive service. W 2728

KAYTRON ELECTRONICS. Capacity available electronic wiring and assembly. Top-class work. Long or short runs. Collection reasonable distance London. 223 Brixton Hill, S.W.2. W 1963

LAYOUT AND PROTOTYPE WIRING and assembly. Small production runs. Consultants for those wishing to start their own coil winding departments. Lawrence Electronics, 53 Hornsey Road, London, N.7. Phone NORth 3445. W 1966

METALWORK. All types cabinets, chassis racks, etc., to your own specifications. Phillpot's Metal Works Ltd., Chapman Street, Loughborough. W 3592

WINDING CAPACITY AVAILABLE at very competitive rates. Quick delivery. Multi-winding, relay winding, layer winding and wave winding. Also automatic wire cutting, stripping, soldering and tagging of bare and P.V.C. covered lead wires. Nesco Products Ltd., 149 Stanwell Road, Ashford, Middlesex. Ashford, Middlesex 3555/2640. W 1958

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CITY AND GUILDS (Electrical, etc.) on "NO PASS—NO FEE" terms. Over 95 per cent successes. For full details of modern courses in all branches of Electrical Technology send for our 144-page handbook—FREE and post free. B.I.E.T. (Dept. 337c), 20 Wright's Lane, London, W.8. W 316

FREE! BROCHURE giving details of course in Electrical Engineering and Electronics, covering A.M.Brit.I.R.E., City and Guilds, etc. Moderate fees. Write to E.M.I. Institutes, Dept. EE29, London, W.4. (Associated with H.M.V.) W 4953

T.V. AND RADIO—A.M.Brit. I.R.E., City & Guilds, R.T.E.B. Certificate, etc., on "No Pass —No Fee" terms. Over 95 per cent successes. Details of Examinations and Home Training Courses in all branches of Radio and T.V. Write for 144-page handbook—Free. B.I.E.T. (Dept. 337H), 29 Wright's Lane, London, W.8. W 187

THE COLLEGE OF AERONAUTICS. The Board of Entry of the College invites applications from suitable candidates for the two-year course which begins in October, 1958, and ends in June, 1960. The course is intended for selected students of graduate standard. Candidates who do not possess a University Degree may offer alternative evidence of educational attainment, for example, a good Higher National Certificate with a satisfactory record of apprenticeship or equivalent experience in industry. All applications are considered by the Board of Entry which may call candidates for interview. The College, a post graduate institution, is devoted to the study of aeronautical science and engineering. The curriculum covers the five main subjects of Aerodynamics, Aircraft Design, Aircraft Electrical Engineering, Aircraft Propulsion and Aircraft Economics and Production. Instruction in the first year is designed to provide all students with a broad background of knowledge in all these subjects, with opportunity for limited specialization in two or three of them. In the second year students specialize more particularly, usually in one subject. The teaching in the syllabus is designed to fit students for a career in either Aircraft or Guided Weapon engineering. Experiments in the air are an important part of the work, both in the first year when all students take part in them and in the second year when they are linked to the specialist work of the departments. Students who satisfactorily complete the course receive the Diploma of the College. Further particulars and details of the procedure for enrolment may be obtained from The Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. W 2745

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ATTENUATOR VANES, precision in excelsis, from Jencons (Scientific) Ltd., Mark Road, Hemel Hempstead. Tel.: Boxmoor 4621. W 2739

GUARANTEED MAGSLIPS at low prices. 3 in Resolver No. 5 (AP 10861), 50v, 50c/s. Unused. each in tin, 35s. post 2s. 1d. Large stocks of these and other types.—P. B. Crawshay, 94 Pixmore Way, Letchworth, Herts. Tel.: 1851. W 321

ILLUSTRATED CATALOGUE No. 13. Containing over 450 items of Government Surplus and Model Radio Control Equipment 2s. 2d. Refunded on purchase of goods 2s. 6d. overseas seamail. Arthur Sallis Radio Control Ltd., Dept. EE, 93 North Road, Brighton. W 332

MAGSLIPS, SELSYNS and many other items connected with automatic and remote control mechanisms are marketed by Servo & Electronic Sales Ltd. Brochure available on request. See our display advertisement on p. 14. W 202

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PORTAWAY Earthing System for Electrical Safety, comprising Earthing Conductors, range of Bonding Clamps and Earth Electrodes. Good delivery. New brochure available from Porter Electrical Products Limited, 2 North Park Road, Harrogate. Phone: 3853. W 312

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WELL-KNOWN FIRM of Precision Engineers and Instrument Makers (London area) are desirous of entering into a Licence Agreement or purchasing outright, Patents relating to electrical and/or mechanical devices of a Precision Instrument character, or of a consumer goods nature. Adequate capital and production facilities are available to develop, produce and market suitable devices. Communications should be addressed, in the first instance, to Major S. F. M. Neill, Louis Newmark, Ltd., Croydon, Surrey. W 2172

WANTED

COPY of "Electronic Engineering," October, 1955, for Electrical Engineering Department Library, Robert Gordon's Technical College, Aberdeen. W 1961

AGENCIES

TECHNICAL REPRESENTATION REQUIRED for North England and Scotland on exclusive agency basis. Must be familiar with electric/electronic rotating components, synchros, servo components and mechanisms. Full details to: Sales Manager, R. B. Pullin & Co. Ltd., Phoenix Works, Great West Road, Brentford, Middlesex. W 2747

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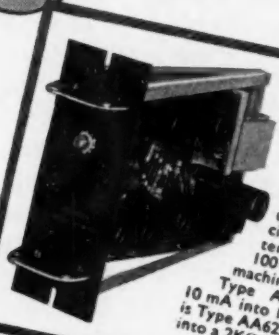
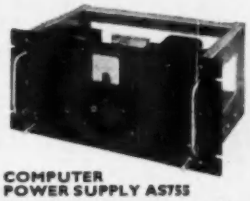
YOU BUILD YOUR COMPUTER WITH OUR STANDARD UNITS



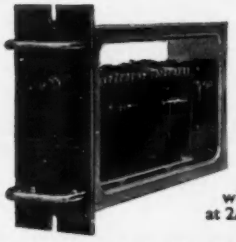
DRIFT-CORRECTED COMPUTER AMPLIFIER AA621

A high-performance D.C. amplifier of completely new design using the latest printed circuit techniques. Long term drift is less than 100 μV and output about machine datum is ± 100 V. Type AA621 will deliver 10 mA into 10KΩ; also available is Type AA622, delivering 50 mA into a 2KΩ load.



COMPUTER POWER SUPPLY AS755

Uses germanium junction rectifiers and provides 300 V at 0·5A with excellent output stability and low ripple content. Two units cater for the normal differential operation of 20 Computer Amplifiers.



HEATER SUPPLY UNIT TS722

To ensure top stability and freedom from interaction between Computer Amplifiers each is supplied from an individual heater winding; output is 6·3V at 2A on each of 6 outlets.

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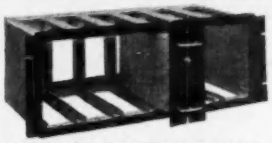
A simple but effective Ventilating Panel which deflects hot air to the front and rear of assembled computer racking.



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Houses five Computer Amplifiers and fits standard 19" P.O. rack. Provided with mains and H.T. links, also patching and test socket panels.

Also available:
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The Solartron Computer Service offers you a comprehensive range of precision "building bricks" for building your own analogue computer or simulator—or extending the machine you are already operating. All units in the range are capable of independent use if desired but have been designed around a standard 100V machine unit and use ± 300V H.T. supplies.

SOLARTRON

THE SOLARTRON ELECTRONIC GROUP LTD. THAMES DITTON. SURREY

Tel: Emberbrook 5522 **Cables: Solartron, Thames Ditton**

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Electronic Tube Applications Engineer with proven ability in original circuit design, required to direct a team of specialized engineers. Work covers the application of pulse techniques to industrial and research problems. Send details of original articles accepted by the technical press and/or any patent specifications.

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TEST ENGINEER

to take charge of a group of operators engaged on life and pre-shipment testing of electronic tubes. The applicant must be able to specify test procedures and preferably have some knowledge of statistical and vibration testing methods.

There is a five-day, 38½ hour week, canteen, social and sports club facilities and pension and superannuation schemes for established employees.

Write giving summary of training and experience quoting Ref. LK/E1 to

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NEW PRODUCTS

New products and patents suitable for large-scale exploitation are sought by internationally known company with 30 years experience in the miniature electronics and electro-mechanical field, due to expansion of manufacturing capacity. Facilities include highest class electronic assembly of miniature transistorized and other equipment, fine wire winding, vacuum encapsulation and impregnation, press and mould tool design and manufacture, injection and transfer moulding, precision machine shop production, and design and development facilities for electronic, electro-acoustic and instrument work.

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Electronic Engineering
28 Essex Street, London, W.C.2

MSL have been retained to advise on the appointment of a

MANAGING DIRECTOR

for a company manufacturing and marketing domestic television and radio receivers. The company has a history of pioneering in the radio field and its products are internationally known.

Candidates must have had top management experience in the electrical industry where marketing problems have formed part of their responsibility. This experience must be based on a sound knowledge of production techniques.

Salary £3,000 approximately, with appropriate benefits.

Age range 35—45.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference MM.680, to R. S. Clifton.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W. 1.

ELECTRONIC RESEARCH

Interesting jobs for young scientists

Attractive research jobs for able and ambitious young scientists are available in Hollerith electronics. Original work is encouraged. Laboratories are well-equipped for electronic research. Salaries are excellent and prospects outstanding. Senior men will operate as group leaders. Postgraduates are required as group members. Groups are small and highly specialised. Applicants will appreciate the considerate employment, good pension scheme, help with housing, and other amenities that go with these posts.

Write to the Head of Research, The British Tabulating Machine Co. Ltd., Electronic Research Laboratory, Gunnels Wood Road, Stevenage, Herts.

Hollerith electronic computers

THE UNITED KINGDOM ATOMIC ENERGY AUTHORITY

(INDUSTRIAL GROUP)

OFFERS AN ATTRACTIVE APPOINTMENT

in the Research and Development Branch for a

COMPUTER MAINTENANCE ENGINEER

who will be responsible to the Computer Manager for liaison with the manufacturers during the installation and commissioning of a

FERRANTI 'MERCURY' COMPUTER

shortly to be installed at

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After the guarantee period he will assume full responsibility for the maintenance of the machine. Supporting staff will be recruited later to provide a shift maintenance service.

A recognised engineering apprenticeship or comparable training and experience of the maintenance of complicated electronic equipment, preferably involving pulse circuits, are essential. Extensive experience of electronic computer maintenance is very desirable but a period of preliminary instruction on the 'Mercury' will be given by the manufacturers

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The appointment is permanent and pensionable and will carry a salary commensurate with qualifications and experience.

A house or assistance towards legal expenses on house purchase may be available.

Send postcard for application form, quoting reference 2179, to RECRUITMENT OFFICER at the above address.

Closing Date: 10th February, 1958

MSL have been retained to advise on the appointment of a

GENERAL MANAGER

for a medium-sized company in the north, manufacturing high quality small electrical components, and forming part of an important group of companies in this field.

Candidates should now be in a position as General Manager or Assistant Managing Director in a manufacturing unit where they carry responsibility for overall management problems. This should have been preceded by production experience in the electrical or electronics industry together with a knowledge of the manufacture of high quality small components and assemblies.

Salary £3,000 with appropriate benefits.

Age range 35-45.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference MM.685, to R. S. Clifton.

MANAGEMENT SELECTION LIMITED

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PLESSEY

ASSISTANT CHIEF ENGINEERS

Applications are invited from Senior Engineers for two vacancies at our Havant factory. These provide opportunities to head teams of Design and Production Engineers and accept responsibility for the design, production engineering and planning of small electro/mechanical devices for the Radio and Communications Industries.

We are seeking men with considerable experience of design and application of components in both Commercial and Ministry equipment and preferably with experience of production engineering of light mechanical assemblies.

These positions carry considerable responsibility, offer a substantial salary and a challenging opportunity with an expanding organisation.

Applications should be addressed to the General Manager, Plessey Co. Ltd., New Lane, Havant, near Portsmouth, Hants.

ELLIOTT BROTHERS (LONDON) LIMITED

COMPUTER ENGINEERS

REQUIRED

New opportunities exist in this expanding enterprise for Engineers and Technicians to be engaged at Borehamwood on commissioning of electronic digital computers. Experience in computing, radar, television or communications engineering is necessary for all positions. The type of experience and academic qualifications will determine the initial level of appointment. Full training will be given for a progressive career in which prospects are linked with the growing use of these machines in industry and commerce.

Please write to the Personnel Manager (ref: 616) at ELLIOTT BROTHERS (LONDON) LTD. Borehamwood, Herts., or telephone ELStree 2040, Ext. 13

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required to join a small team engaged on the design and development of instruments for research in the oil industry at

THORNTON RESEARCH CENTRE

(near Chester)

Workshop experience, and some drawing office experience, on instruments or small electro/mechanical units is essential. Five-day week and attractive pension scheme. Write to:-

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If you are an outstanding Circuit Engineer and would like to work on the most advanced radar display and data processing equipment, write to:-

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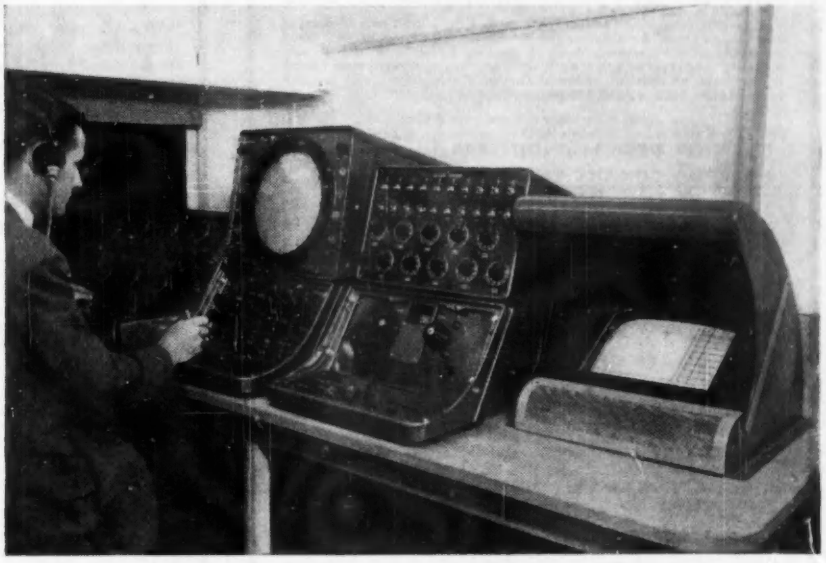
Tolworth, Surrey



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AUTOMATION

SENIOR ELECTRONIC ENGINEER

We are seeking an outstanding senior engineer with proven ability in original design work of an advanced nature in any of the following fields:

Electronic Industrial Control equipment

Electro mechanical devices

Servo mechanisms

He should have experience in developing electronic equipment from basic circuitry together with a working knowledge of production design requirements.

Solartron is a young and vigorous organization with a programme of rapid expansion ahead, and offers excellent career opportunities.

Although based initially at our Dorking, Surrey research laboratories, it will be necessary to move in about 9-months time to a new factory now being built at Farnborough, Hants.

Please apply to:

THE GROUP PERSONNEL OFFICER

THE SOLARTRON ELECTRONIC GROUP LTD

Queens Road, Thames Ditton, Surrey.

The following vacancies exist in the

EDISWAN-MAZDA

Applications Laboratories

1. **CIRCUIT DEVELOPMENT ENGINEERS**
for Television Receiver Problems.

2. **CIRCUIT DEVELOPMENT ENGINEERS**
for Sound Receiver Problems.

3. **ENGINEERS**
for Development Work on U.H.F.

4. **ENGINEERS**
for Development Work on Transistor Circuits and their Application in the Industrial and Entertainment fields.

5. **ENGINEERS**
for Development Work on Valve Circuits and their Application in the Industrial and Entertainment fields.

6. A vacancy also exists in connection with the preparation of Technical Data for Publication.

The above Laboratories are very well equipped with the most up-to-date facilities and provide congenial working conditions. Owing to the expanding interests, excellent prospects are available for suitable candidates.

Starting salaries in accordance with experience, qualifications and age.

Candidates with engineering or physics degree, H.N.C., or equivalent qualifications should apply in writing to the Personnel Superintendent, Siemens Edison Swan Limited, Brimsdown, Enfield, Middlesex. Applications will be treated as confidential.

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THORN ELECTRICAL INDUSTRIES GROUP

This rapidly expanding Company has many vacancies in its Laboratories and Design Office for discerning staff. Openings are arising due to the expansion of the Company both in its own former field and on new projects. Messrs. Nash & Thompson Ltd. have for years been leaders in the realm of physical, chemical-electronic instruments, and are now exploring the field of pulse control techniques.

Some of the vacancies are listed below:

1 SENIOR DESIGN ENGINEERS
2 SENIOR CIRCUIT ENGINEERS — Required for work in the field of transistor circuitry and transistor pulse technique.

3 SENIOR SYSTEM ENGINEERS Preferably with experience in Control Engineering.

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7 GRADUATE CHEMIST for work on the growing of large crystals. Salary scale £700—£1,000.

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9 DESIGN DRAUGHTSMEN (ELECTRICAL)
10 DESIGN DRAUGHTSMEN (MECHANICAL)
11 DRAUGHTSMEN — *Salary according to age and experience*

Write to Chief of Research

Messrs. NASH & THOMPSON LTD.

Oakcroft Road, (off Kingston-By-Pass), Chessington Surrey.

giving age, qualifications and details of experience and salary required

ELECTRONICS ENGINEER PLUS ! ! !

British company require a first-class Electronics Engineer to work on the development of an entirely new Electronic Machine.

Applicants must have experience in the design of Prototype Circuits and possess adaptability and initiative. Permanent position offered with excellent prospects of promotion in a new expanding organisation.

High starting salary commensurate with qualifications and experience. Pension Scheme.

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CHIEF TEST ENGINEER

(INDUSTRIAL ELECTRONIC EQUIPMENT)

Required to take charge, technically and administratively, of a department engaged in the testing and proving of both small and large control equipment.

Applicants should have had a sound Electrical/Electronic Engineering training, and should be familiar with modern electronic control equipment, including servo systems, control equipment for electrical machines, machine tool control, resistance welding controls, photo-electric equipment, etc. etc.

This is a senior staff position with an expanding organization for a man with initiative and a keen interest in the automatic control field. The salary will be commensurate with qualifications, experience and ability.

Applications in strict confidence to Ref. 40/SB/JH

LANCASHIRE DYNAMO ELECTRONIC PRODUCTS, LTD.

RUGELEY, STAFFS

THE PLESSEY COMPANY LIMITED

are extending their

ELECTRONICS RESEARCH LABORATORY

at Roke Manor, near Romsey

and have a vacancy for a leader of a new section. This new section will be divorced from all applications work and will be encouraged to carry out basic work on electronic circuits, particularly in connection with new components and with high-speed circuits. Full facilities for this work will be provided. Only first-class men need apply, but the successful candidate will be offered a high salary and will be expected to develop the section in a University-like atmosphere. He and members of his section will be given a large measure of freedom in choosing the subject of their researches and freedom to publish the results of the work.

Applications should be made in writing to

Dr. Denis Taylor (Electronics Group),
The Plessey Company Limited,
Vicarage Lane, Ilford,
Essex.

ENGLISH ELECTRIC COMPANY LIMITED

GUIDED WEAPONS DIVISION

DRAUGHTSMEN & DESIGNERS

Following the announcement of contracts for the introduction of the **THUNDERBIRD** missile into service with the R.A.F. and the Army, there is an increasing demand for Draughtsmen and Designers at both our Luton and Stevenage establishments.

Applications are invited for positions in our electronic, servomechanism and instrument departments from electronic, electrical and mechanical draughtsmen who have had at least two years relevant draughting experience and who have served an engineering apprenticeship and obtained an Ordinary National Certificate.

For some of the more senior vacancies about seven years experience is essential.

The Company operates a comprehensive pension scheme.

In most cases HOUSING may be available, BUT EARLY APPLICATION IS ESSENTIAL. Please write giving details to Dept. C.P.S. 336/7 Strand, London W.C.2, quoting Ref: EE699J.

Packaged Computers

IBM

British Laboratories

IBM British Laboratories is engaged on research and development programmes aimed at new techniques and equipments for office, industrial and integrated data processing systems.

ELECTRONIC ENGINEERS are required with **H.N.C.**, or equivalent qualifications and several years experience in circuit development (not necessarily computing). Some experience with transistors would be useful, but ability to learn unfamiliar techniques quickly is more important than specialised knowledge. Age 23-30.

The posts offer good prospects for advancement. It is expected that the organisation will be moving 50 miles North of London in 1–2 months. Non-contributory pension and life assurance schemes are in operation and attractive salaries will be paid according to qualifications and experience.

Applications in strict confidence to:-

The Personnel Manager,
IBM British Laboratories (W.T.L.C.)
101 Wigmore Street, London, W.1.

MULLARD EQUIPMENT LIMITED

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who are expanding their development of new types of advanced electronic equipment have IMMEDIATE vacancies, and will have others during the next six months, for both

MECHANICAL and ELECTRONIC DEVELOPMENT ENGINEERS

to work in the Engineering Development Laboratories in one of the following fields :—

(a) Electronic Industrial Control Systems, including machine and process control, using computor techniques.

(b) Nuclear reactor instrumentation.

(c) Transistorised Equipment.

(d) Microwave Equipment and Components, including the development of linear accelerators.

(e) Radio Communication Equipment, exploiting advanced techniques.

(f) Nucleonics, including radiation monitors.

(g) Measuring Instruments.

Applications are invited both from those with experience in these or allied fields who are capable of taking responsibility for their own projects and commanding salaries in excess of £1,000 per annum, as well as from those with limited experience and a technical education of graduate standard.

Some of these vacancies will be suitable for ex-Service personnel and some for female physicists or electrical engineers.

Applications should be made in writing to the Personnel Officer quoting, reference L.M.1.

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The following Staff are required to assist in an increasing programme of engineering and manufacture of high-grade television equipment for Broadcast and Laboratory Application.

Excellent opportunities exist for men with the right ability and experience

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to be responsible for the engineering development and production of television and allied equipment which would include some progressing and the supervision of some technical staff. Applicants required to possess qualifications to H.N.C. or equivalent standard (suitable practical experience considered in lieu).

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preferably with test experience, conversant with the use of Laboratory Test Equipment, required to work with minimum supervision.

5-DAY WEEK. PENSION SCHEME. GOOD CANTEEN. 1 MIN. BUS AND RAIL SERVICES

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required by

A. V. ROE & CO., LTD.

to lead a team of designers and draughtsmen engaged on the design and development of guidance systems and associated electronic equipment; must be fully experienced in electronics and in the latest techniques in this field and have a good knowledge of airborne equipment and conditions.

The position offers an opportunity to engage in interesting work on advanced designs and we expect applicants to have the appropriate qualifications: all applications will be treated in strictest confidence.

The Division is situated within easy reach of Manchester and the Derbyshire Hills and the Company provides excellent canteen facilities and a superannuation scheme.

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The Chief Engineer, A. V. ROE & CO. LTD.,
Weapons Research Division, WOODFORD, Cheshire.

quoting ref. RHF/R79/E

A. V. ROE & CO. LIMITED
WEAPONS RESEARCH DIVISION
(Guided Missiles)
WOODFORD · CHESHIRE

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Systems Research Group invites applications for the following posts from graduates, and from technicians with H.N.C. qualifications:-

A. **GRADUATES IN MATHEMATICS OR PHYSICS** for theoretical work in connection with stochastic processes and rotational dynamics.

B. **ELECTRONIC ENGINEERS** for work on servo design and temperature control problems.

C. **A MECHANICAL ENGINEER,** urgently needed for experimental work on the design of high precision instruments and structures of unusual design.

The Division is situated within easy reach of Manchester and the Derbyshire hills, and the Company provides excellent canteen facilities and a superannuation scheme.

Applications to:- **The Personnel Manager,**
A. V. ROE & CO. LIMITED,
Greengate, Middleton, Manchester.
Quoting Ref. NS/WRD/R.81/E

Lion Electronic Developments, Ltd., who have complete United Kingdom Sales coverage, and excellent manufacturing facilities, wish to negotiate for manufacturing and/or selling rights for Electronic Instruments, Industrial, Telecommunications and Automation Products, and Resin Encapsulated Electronic Circuits and Components.

Would interested Organisations please communicate with reference RQM

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This equipment enables a remote shaft to be turned in accordance with the position of a local Magslip transmitter and comprises a two channel servo amplifier, two phase induction motor and induction generator feedback together with remotely located coarse and fine coincidence transmitters. Output torque 50 lb. in. Full details on request from:—

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Our products include—
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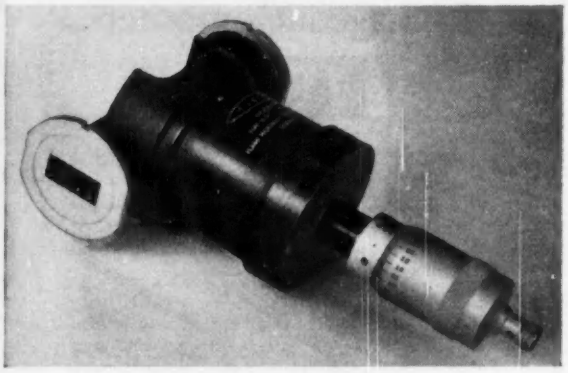
WAVEMETER TYPE 16/7



SPECIFICATION

Mode of operation	TEoi	Calibration accuracy	1 Mc/s
Waveguide	No. 16		5 Mc/s
Q unloaded	30,000	Discrimination	200 Kc/s
Q loaded	10,000	Micrometer Divisions	0.0002"
Frequency range	8.5 KMc/s to 12.5 KMc/s, 8.5–10 KMc/s, 10–12.5 KMc/s		

PRICE **£65** (in the U.K.)
DELIVERY TWO MONTHS OR LESS
other details on request

Precision Instruments are made in all Waveguides from No. 10–12

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133 Munster Road, Teddington, Middlesex, England.
Telephone No.: Kingston 7217

In your miniaturized and transistor circuits, requiring high capacity in small volume, consider the application of

Solid TANTALUM CONDENSERS

The CHIMEL patented condensers, made of porous, sintered tantalum, prepared by novel processes from metal powders, cannot dessicate or leak as electrolytic or wet condensers; those made of thin tantalum foil may lose 50 per cent of their capacity after 5000 hours of operation. The variations of the CHIMEL tantalum condensers do not exceed ±100 per cent even under maximum voltage and at 85° Centigrade.

The CHIMEL condensers have excellent stability, do not corrode and are impact resistant. They operate between −80°C and +85°C; type "HT" up to 125°C.

The production range includes condensers from *.005 at 60 MF* and *6 to 35 VDC.*

The CHIMEL condensers, international patents pending, will be manufactured also in other Western European countries, under licence.

Description and information from CHIMEL S.A., 4 place du Molard, Geneva (Switzerland).

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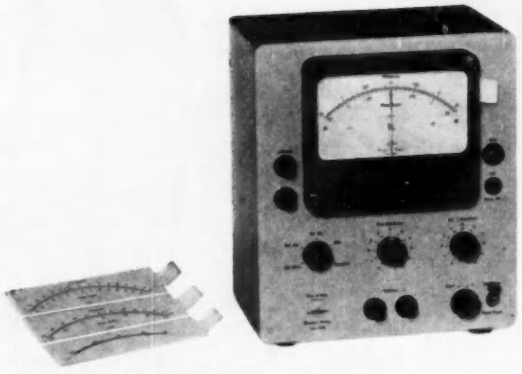
TWO DEVIATION TEST BRIDGES

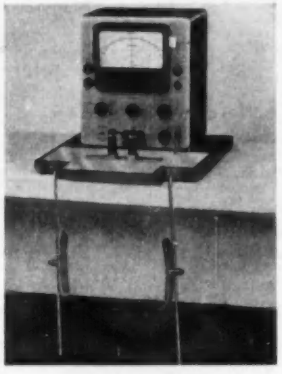
Type 1504 and 1506

for

COMPONENT PRODUCTION CONTROL



Type 1504



Type 1504 and 3901

Resistors, Capacitors and inductances can now be classified at a rate of

4000 Units per hour

when the Test Bridge Type 1504 or 1506 is used in connection with the knee-operated Test Jig Type 3901. The impedance and phase angle deviation from a known R, L or C standard can be read **directly in** % off the instrument meter.

Type 1504 operates at a measuring frequency of 1 kc/s and Type 1506 at a frequency of 100 kc/s.

Knee-operated

Three calibrated, interchangeable scales are supplied with the instrument enabling impedance deviations within the following ranges to be measured: −1.5% to + 1.5 %, − 7 % to + 7 % and −25 % to + 35 % and phase angle deviations from (−1.5 to + 1.5) × 10^{-2}, (−7 to + 7) × 10^{-2} and (−25 to + 25) × 10^{-2} radians.

In addition three blanco scales are provided in order that the customer may calibrate them for particular requirements.

Test ranges:	Type 1504	Type 1506
Resistance:	10 Ω—10 MΩ	10 Ω—50 kΩ
Capacitance:	50 pF—10 μF	25 pF—0.1 μF
Inductance:	2 mH—100 H	20 μH—80 mH

For further information concerning these and other instruments apply to:

B K **Brüel & Kjær**

Adr.: NÆRUM, DENMARK · Teleph.: NÆRUM 500 · Cable: BRUKJA, COPENHAGEN

SALES AND SERVICE: B & K Laboratories, 57 Union Street, LONDON S. E. 1.

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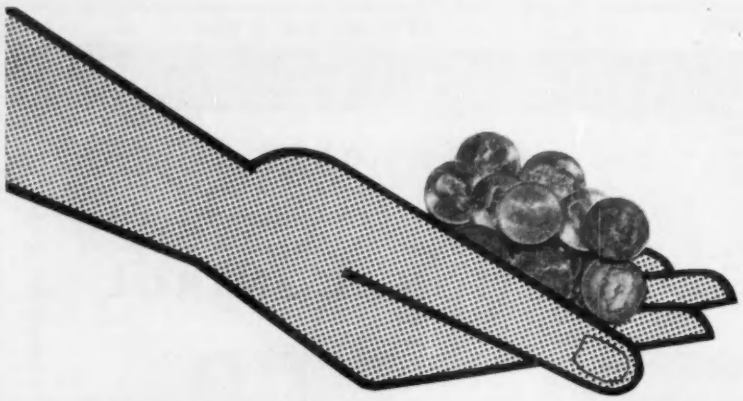

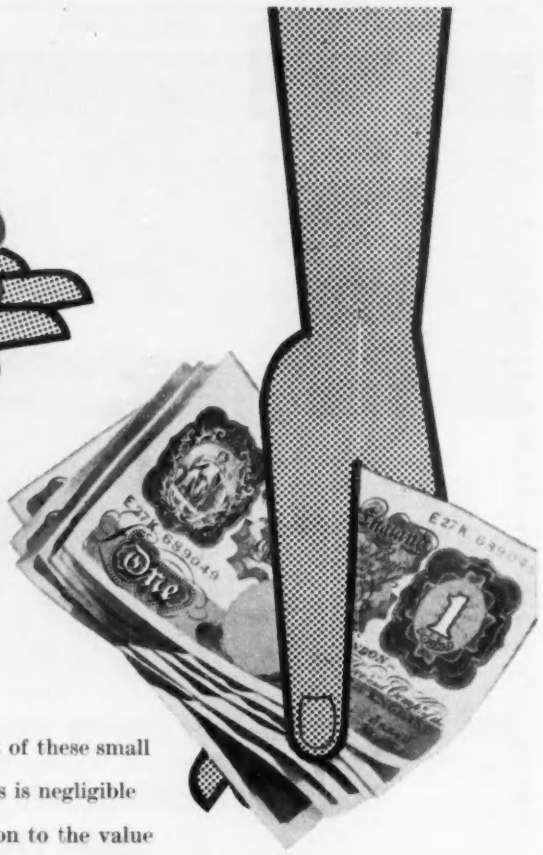

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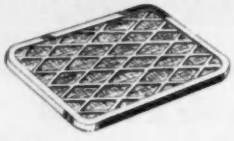
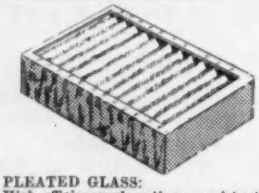
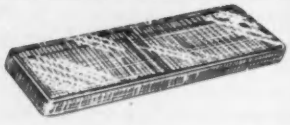
. . . . MAY SAVE
POUNDS LATER ON



18 NYL:
Specially knitted nylon, resistant to humidity and corrosion, in enamelled steel frame. Two sizes and duties.



PLEATED GLASS:
High efficiency glass tissue, resistant to humidity and corrosion, in plastic case. Three sizes and duties.



NYLON PADS:
Knitted nylon, resistant to humidity and corrosion, on aluminium frame. Three sizes and duties.

The cost of these small air filters is negligible in relation to the value of the equipment they protect. Yet, in terms of reduced maintenance, longer working life and all-round customer satisfaction their worth runs into many pounds.

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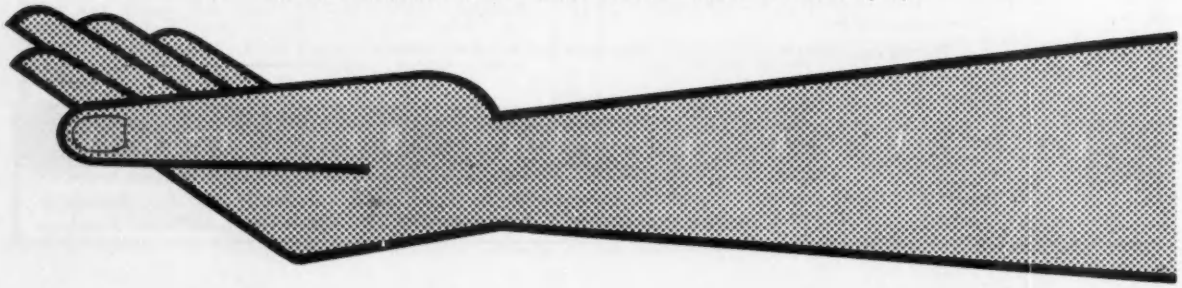

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WITH THE FOLLOWING FEATURES . .

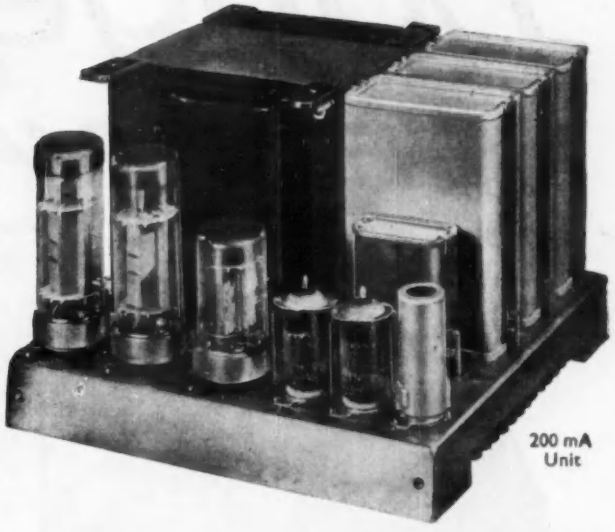
OMISSION OF CHOKE—resulting in ability to operate down to zero current with complete stability—freedom from transient voltage surges due to shock loading—miniaturised units.

CONSERVATIVE RATING—all units are guaranteed to maintain stability for ±10% mains variation. The majority will operate to at least −15%.

LONG LIFE—Inter Services approved paper condensers used throughout. Adequate derating of series valves where more than one is used.

FREEDOM FROM DRIFT—exclusive use of double triode difference amplifiers in feedback circuit ensures long term stability.

IMPEDANCE CONTROL—a preset potentiometer allows for smooth adjustment of impedance from positive to negative values. Can be used to offset the impedance of a series milliammeter.



200 mA Unit

MODEL	D.C. OUTPUT		A.C. OUTPUTS	EFFECTIVE RESISTANCE	VOLTAGE STABILITY	RIPPLE	SIZE	PRICE *Ex-works*
	VOLTS	CURRENT						
M23	±150V	0-50mA	6·3V2A & 6·3VIA	<0·1Ω	<0·02%	<1mV	6″×5½″×5¾″ht.	£30–0–0
M23A	±200V	0-50mA	6·3V2A & 6·3VIA	<0·1Ω	<0·02%	<1mV	6″×5½″×5¾″ht.	£30–0–0
M33	±250V	0-50mA	6·3V2A & 6·3VIA	<0·1Ω	<0·02%	<1mV	6″×5½″×5¾″ht.	£27–10–0
M24	±150V	0-100mA	2×6.3V 3A C.T.	<0·1Ω	<0·02%	<1mV	7⅜″×6¾″×6¼″ht.	£33–10–0
M24A	±200V	0-100mA	2×6·3V 3A C.T.	<0·1Ω	<0·02%	<1mV	7⅜″×6¾″×6¼″ht.	£33–10–0
M34	±250V	0-100mA	2×6·3V 3A	<0·1Ω	<0·02%	<1mV	7⅜″×6¾″×6¼″ht.	£33–10–0
M34A	±300V	0-100mA	2×6·3V 3A	<0·1Ω	<0·02%	<1mV	7⅜″×6¾″×6¼″ht.	£33–10–0
M25	±150V	0-200mA	2×6·3V 3A C.T.	<0·1Ω	<0·02%	<1mV	8¾″×8½″×5¾″ht.	£52–10–0
M25A	±200V	0-200mA	2×6·3V 3A C.T.	<0·1Ω	<0·02%	<1mV	8¾″×8½″×5¾″ht.	£52–10–0
M35	±250V	0-200mA	2×6·3V 3A	<0·1Ω	<0·02%	<1mV	8¾″×8½″×5¾″ht.	£52–10–0
M35A	±300V	0-200mA	2×6·3V 3A	<0·1Ω	<0·02%	<1mV	8¾″×8½″×5¾″ht.	£52–10–0
M36S	±250V	0-500mA	2×6·3V 5A	<0·1Ω	<0·02%	<1mV	14″×11½″×8½″ht.	£88–0–0
M36SA	±300V	0-500mA	2×6·3V 5A	<0·1Ω	<0·02%	<1mV	14″×11½″×8½″ht.	£88–0–0
M38	±250V	0-350mA	2×6·3V 5A	<0·1Ω	<0·02%	<1mV	13½″×8¾″×6¾″ht.	£66–0–0
M38A	±300V	0-350mA	2×6·3V 5A	<0·1Ω	<0·02%	<1mV	13½″×8¾″×6¾″ht.	£66–0–0

ALSO

TYPES M36/36A ±250/300V at 0.5A
M37/37A ±250/300V at 1.0A
With 19″ panels for rack mounting.

AND

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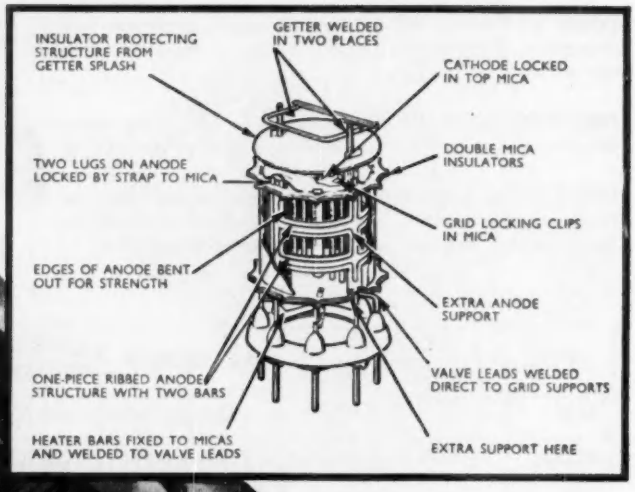
INSULATOR PROTECTING STRUCTURE FROM GETTER SPLASH
GETTER WELDED IN TWO PLACES
CATHODE LOCKED IN TOP MICA
TWO LUGS ON ANODE LOCKED BY STRAP TO MICA
DOUBLE MICA INSULATORS
GRID LOCKING CLIPS IN MICA
EDGES OF ANODE BENT OUT FOR STRENGTH
EXTRA ANODE SUPPORT
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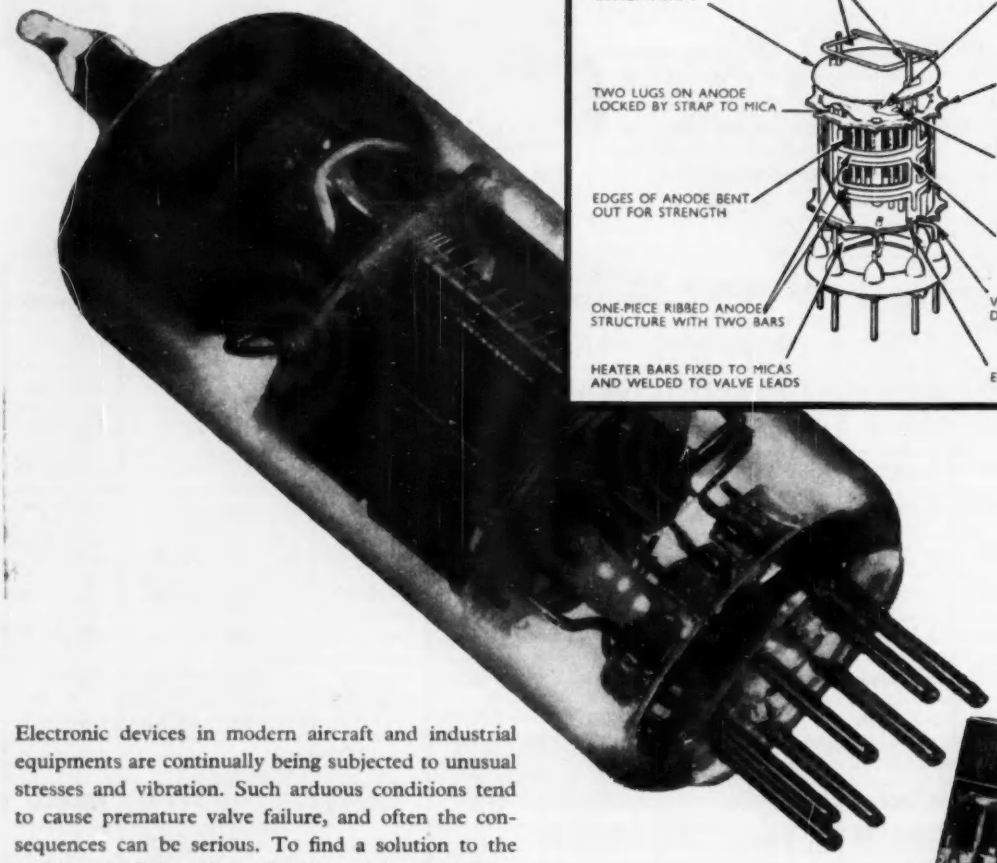
VALVE LEADS WELDED DIRECT TO GRID SUPPORTS
HEATER BARS FIXED TO MICAS AND WELDED TO VALVE LEADS
EXTRA SUPPORT HERE



Electronic devices in modern aircraft and industrial equipments are continually being subjected to unusual stresses and vibration. Such arduous conditions tend to cause premature valve failure, and often the consequences can be serious. To find a solution to the problem the Brimar Valve Division of Standard Telephones and Cables Ltd. undertook special design studies involving work on new electrode structures and materials. An interesting solution to this problem, including the use of a Wiggin tungsten-nickel cathode to withstand stresses at 700-800°C, is described in 'Wiggin Nickel Alloys' No. 42.

OTHER FEATURES IN THIS ISSUE INCLUDE

Fabricating Nimonic Alloys for Jet Turbines
Gas Carburising Furnace at Fords
Welding Nimoply 75
Extended Life for Flare Stack Tips

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TGA 819

where quality counts

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- *Accuracy up to ±0.1 per cent or ±0.01 Ω whichever is the greater.*
- *All values available in the range 0.1 Ω to 3 Megohms with a temperature coefficient of 0.002 per cent °C.*
- *Standard ratings; ¼W, ½W, and 1W.*
- *Low-Inductance windings available in most sizes.*
- *Special Types, higher ratings and American equivalents to order.*

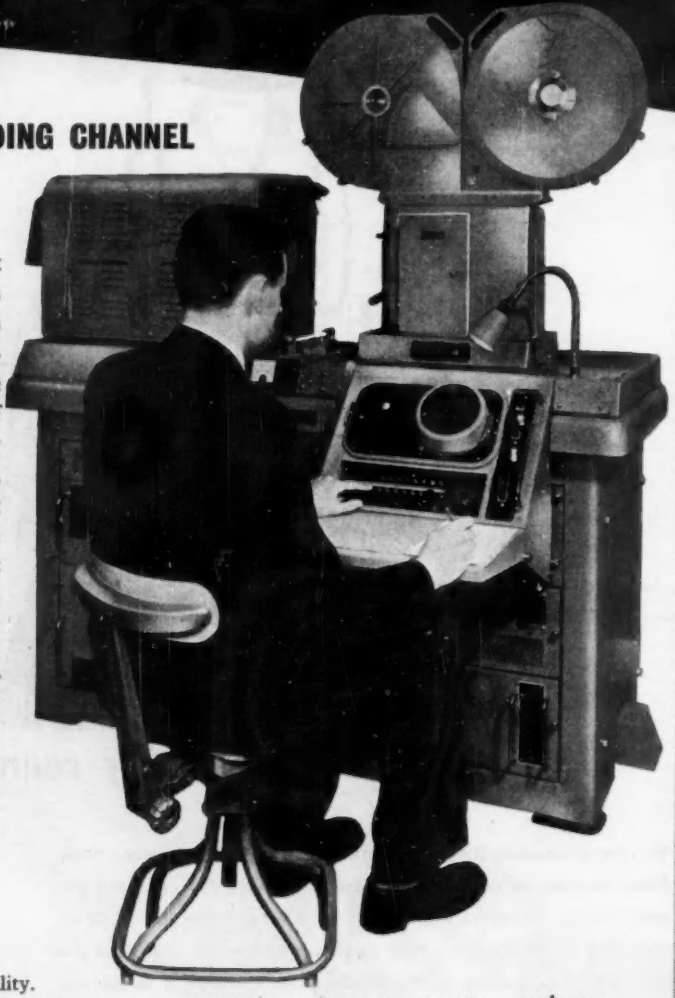
RIVLIN PRECISION WIREWOUND RESISTORS

RIVLIN INSTRUMENTS LIMITED
DOMAN ROAD, CAMBERLEY, SURREY
Telephone: CAMBERLEY 2567/8
London Office: Tel. Swiss Cottage 3038

RIVLIN INSTRUMENTS LIMITED
ELECTRONIC ENGINEERS

MARCONI TELEVISION RECORDING EQUIPMENT

TYPE BD679 RECORDING CHANNEL



16mm film presents a most economical and flexible means of recording television pictures since film costs are low, developing and printing techniques are advanced and a wide range of fine grain film stocks are readily available. Projection, editing, viewing, dubbing and handling are all easily carried out with standard equipment. The Fast Pull-down technique presents great advantages over other systems of recording on film but the mechanical difficulties of moving the film in the short period of frame blanking have hitherto prevented the employment of the technique. These problems have now been successfully overcome by Marconi's.

Features

Exceptionally high picture quality.

Specially developed gearbox enables Fast Pull-down technique to be employed. F.P.D. Mechanism has given over 3,000 hours trouble-free operation.

Pull-down time adjustable, normally set at 2 milliseconds permitting recording of fully interlaced picture. Simple single-lens optical system avoids loss of contrast.

Sound can be recorded on optical track, magnetic stripe or separate synchronous magnetic track.

Conveniently placed input selector switches, monitor and level controls. Sound/Vision cueing device incorporated.

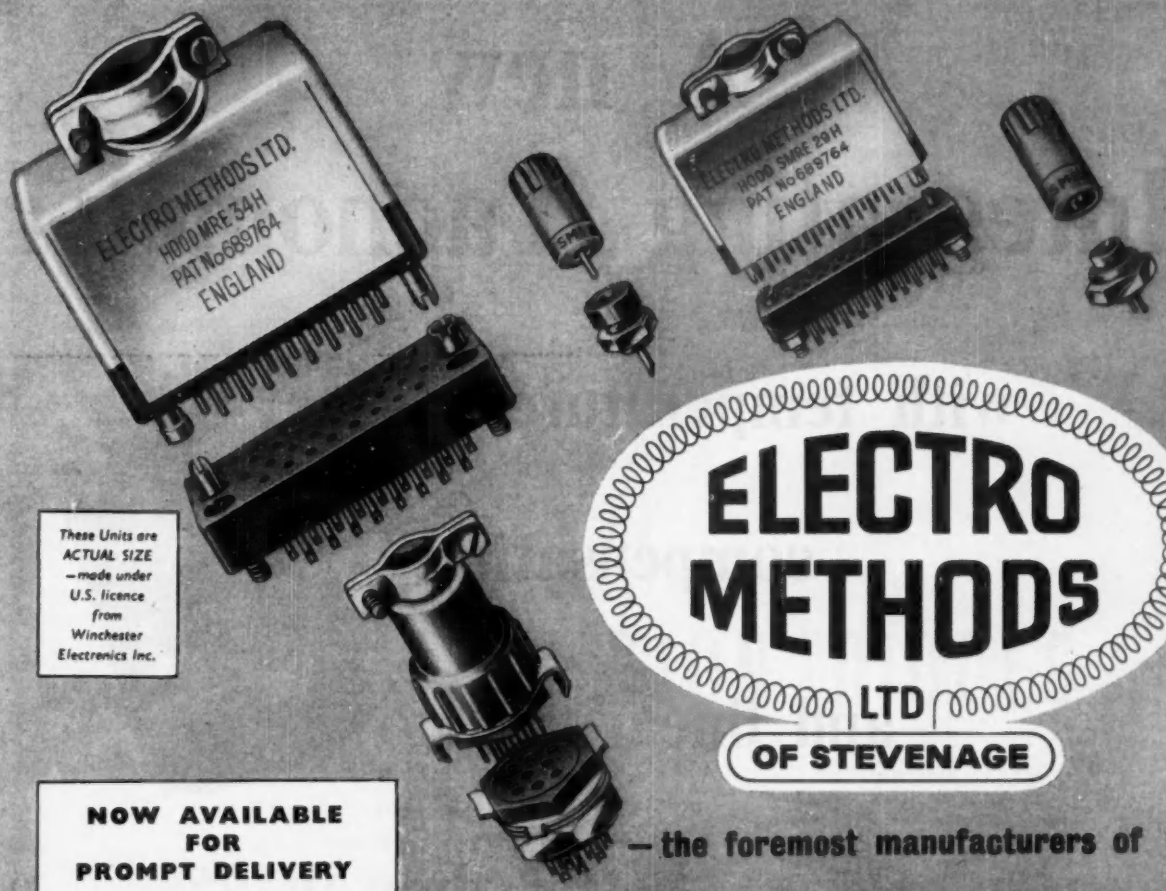
Recording can be made on positive or negative stock of a wide variety, either direct positive, direct negative or reversal. Magazines hold 2,400 ft. (2,000 ft. magnetic stripe) or film may be fed directly into a rapid processor.

MARCONI

COMPLETE SOUND AND TELEVISION BROADCASTING SYSTEMS

MARCONI'S WIRELESS TELEGRAPH COMPANY LIMITED, CHELMSFORD, ESSEX, ENGLAND

LB10



These Units are ACTUAL SIZE —made under U.S. licence from Winchester Electronics Inc.

ELECTRO METHODS LTD OF STEVENAGE

— the foremost manufacturers of

miniature connectors

NOW AVAILABLE FOR PROMPT DELIVERY

* *

SERIES 'MRE'

with 7, 14, 18, 26, 34 & 50 contacts

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Rigid top or side-entry
ALUMINIUM HOODS
complete with cable-clamps

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VIBRATION LOCKS
for 7 to 34 contact top-entry hoods only

* *

SERIES 'SMRE'

with 7, 14, 20, 26, 29 & 34 contacts

•

Rigid top-entry
ALUMINIUM HOODS
complete with cable-clamps

* *

SERIES 'M'

with 5, 7 & 9 contacts

•

Rigid top-entry
MELAMINE HOODS
complete with cable-clamps

•

Locking device optional

* *

SERIES 'SM'

with 1 and 2 contacts

•

Rigid top-entry
MELAMINE HOODS

GOLD-PLATED CONTACTS
made from spring-tempered phosphor-bronze
provide low contact-resistance, prevent corrosion and facilitate soldering.

MELAMINE MOULDINGS
conforming to B.S.S. 1322
provide high arc-resistance, high dielectric and mechanical strength.

Full technical data and illustrated leaflets forwarded on request
ELECTRO METHODS LTD.
17-41 Caxton Way, Stevenage, Herts.
Telephone . Stevenage 780-4

A new Integrating Tachometer

with temperature compensation and linearity

better than 0·12%

SPECIFICATION

Type description	**105T2H Integrating Tachometer**
Excitation (Volts)	24
Frequency (C.P.S.)	400
Input current (Amps)	.130
Input power (Watts)	1.9
Output Gradient (per 1,000 r.p.m.)	1 volt ± .2%
Phase shift with respect to input at 3,600 r.p.m.	0° ± 10′
In-Phase Fundamental at zero speed (mV)	2
Quadrature Fundamental at Zero speed (mV)	6
Total harmonic (mV R.M.S.)	5
In-Phase axis error (mV)	1
Quadrature axis error (mV)	1
Linearity: up to 4,000 r.p.m. (percentage of voltage output at 3,600 r.p.m.)	± .12%
Variation of output gradient with variation in ambient temperature	−55°C to + 80°C ± .3% in magnitude ± 50′ phase shift
Shift in axis error with variation in ambient temperature	−55°C to + 80°C ± 10 mV in phase ± 8 mV in Quadrature
Rotor Moment of Inertia (oz.—in²)	0.094
Weight:	8 oz. for tachometer and 1 oz. for resistor
Drive	can be combined with 1.5″ and 1.8″ diameter servo motors

The latest addition to the Ketay range — of particular interest to Design Engineers currently engaged in the development of advanced computer equipment — is an extremely accurate Integrating Tachometer 105T2H.

Outstanding among its characteristics are temperature compensation and linearity better than 0.12%. Full details of this new Ketay product and of the full Ketay range are freely available on request.

Ketay LIMITED

EDDES HOUSE · EASTERN AVENUE WEST · ROMFORD · ESSEX · TELEPHONE: SEVEN KINGS 6050

K3

The first of the G.E.C. range of SILICON JUNCTION DIODES

For High Temperature Operation with extremely high ratios of forward to reverse resistance.

SX641 SX642 SX643 SX644

These diodes utilise a recently developed glass—pure copper seal which has made possible the production of devices with really outstanding thermal properties.

LOWER VOLTAGE TYPES
SX641 SX642

Suitable for use as Second Detectors at frequencies of up to 10 Mc/s and for the majority of other low power circuit functions including Magnetic Amplifiers.

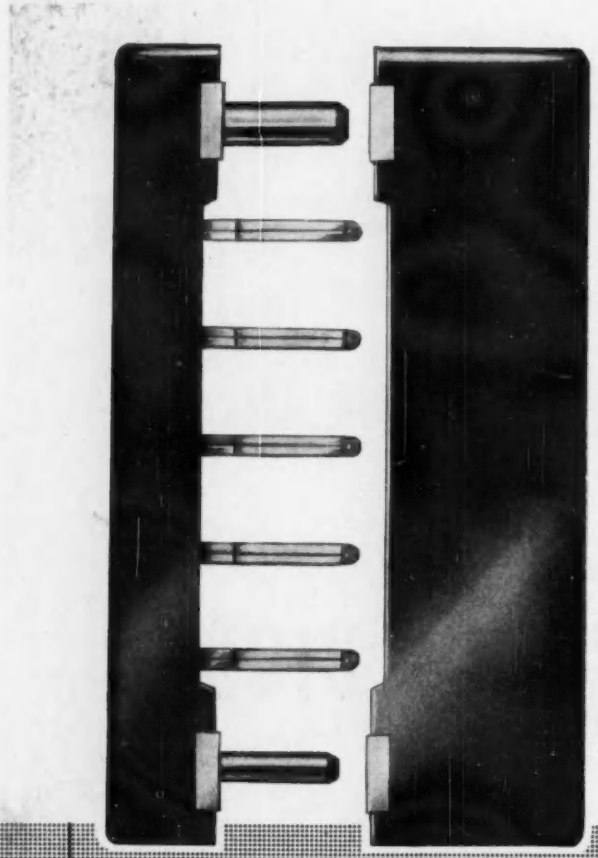
HIGHER VOLTAGE TYPES
SX643 SX644

Suitable for use as H.T. rectifiers in telecommunication type power supplies, and for Blocking and Gating functions.

Typical ratings for capacitive input circuits at ambient temperatures of less than 75°C are given below:—

Circuit Arrangement	Number of Diodes	Max. Rectified Current (mA)	R.M.S. Input Voltage (V)		D.C. Output Voltage (V)	
			SX643	SX644	SX643	SX644
Half-wave	1	100	64	106	90	150
Bi-phase	2	200	64-0-64	106-0-106	90	150
Bridge	4	200	128	212	180	300

For further information, write to the C E C. Valve and Electronic Department
THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2.



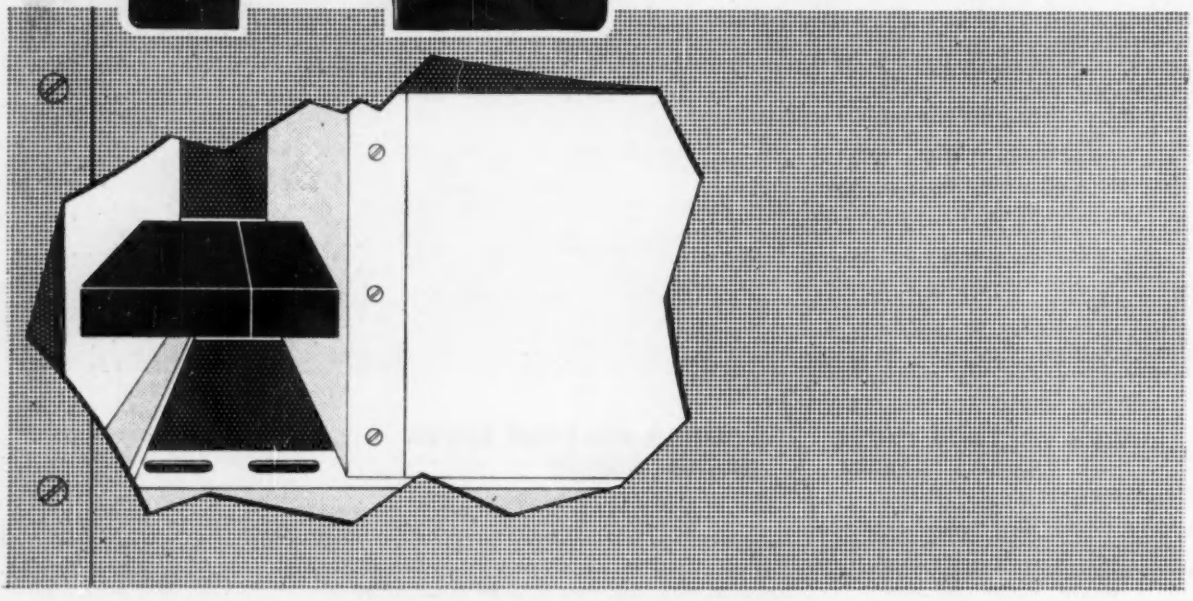
Putting 5 and 5 together

These In-Line Connectors are specially suitable for plug-in unit construction or small rack mounting equipment.

Well proven plug and socket contacts are used and exceptional freedom in dimensional tolerances of fixings etc. has been provided for.

5 and 7 Way versions are available and the Connectors can either be mounted direct to the panel where clearance is provided for contacts or mounted on stand-off pillars.

Location is provided by guide pins which are polarised to prevent incorrect insertion.



A.I.D & A.R.B – APPROVED

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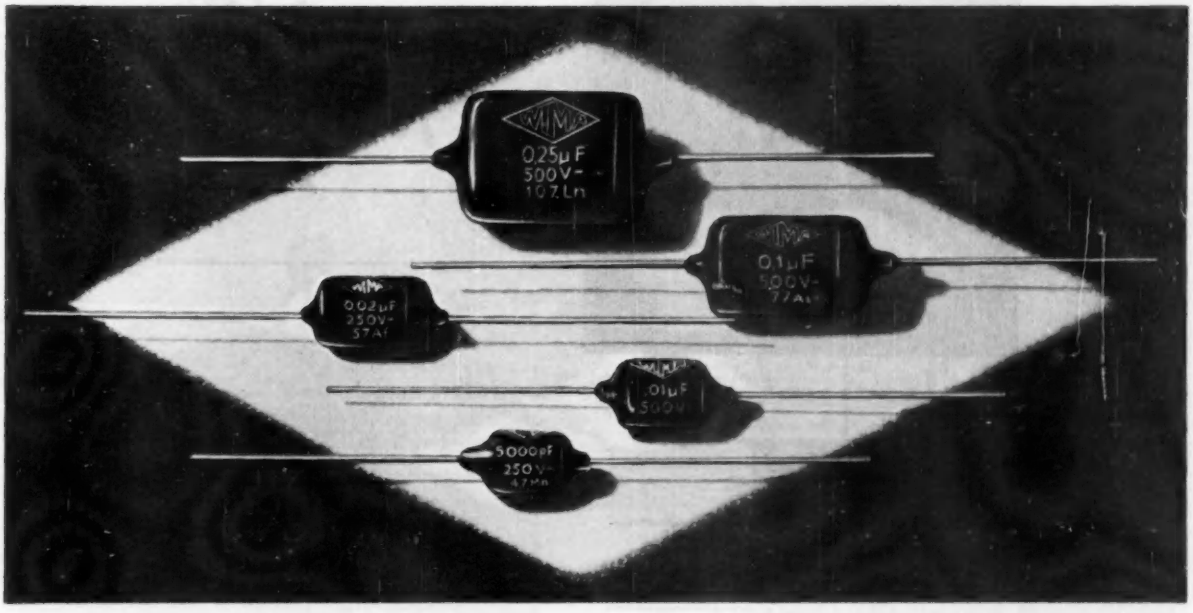
URGENT REQUIREMENTS IMMEDIATELY FROM STOCK
BULK SUPPLIES MAXIMUM THREE WEEKS



TROPYDUR WIMA CONDENSERS

"The only condenser flattered by imitations"

Don't let lack of condensers hold up production. PROMPT AND RELIABLE DELIVERY of WIMA Tropydur Condensers will speed completion of your orders!

The ideal flat-oval dimensions of these paper and foil capacitors enables them to be used to advantage in restricted spaces. Terminal wire points are completely sealed off by our special hot dip process which ensures the highest operational standards, and makes them particularly suitable for all tropical and export equipment.

Wima Tropydur Condensers provide the finest service to the engineer today and provide maximum reliability and performance.

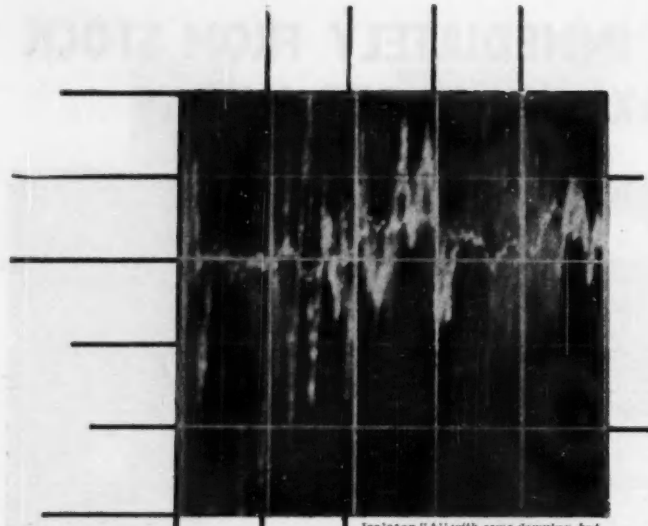
NEW REDUCED SIZES PARTICULARLY SUITABLE FOR PRINTED CIRCUITRY

Capacity range :	50pF to 1 mfd.	Temperature Range:	−20° C to +90° C
Tolerance:		Test Voltage:	5 seconds at three times the rated voltage.
STANDARD :	<0.1 mfd. ±20% ≥0.1 mfd. ± 10%		1 minute at twice the rated voltage.
SPECIAL TO :	±5%		

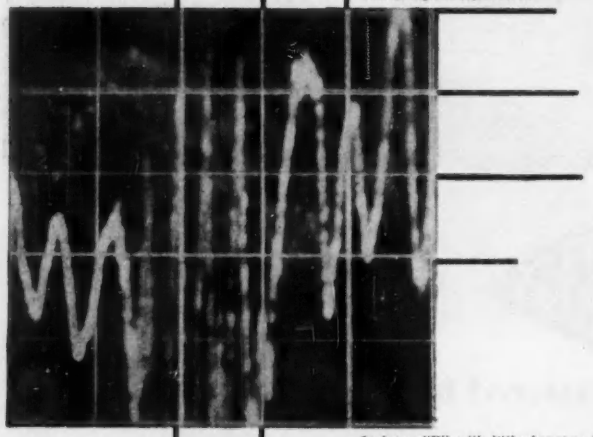
Full Technical Specifications and Prices from **SOLE AGENTS**

W. S. WAYLETT & COMPANY LTD.,

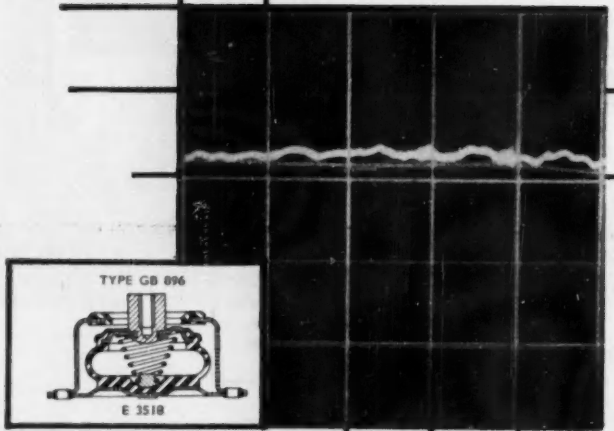
EMPIRE BUILDINGS, DUKE ST. HILL, LONDON, S.E.1. Tel: HOP 5055/6



Isolator "A" with some damping, but snubbing at resonance (15 c.p.s.). Metal to metal impact. Transmitted acceleration approx. 12 g. for sinusoidal input of ±0.026". Envelope contains transients as high as 10,000 c.r.s.



Isolator "B" with little damping, but with rubber buffers to reduce shock at resonance (15 c.p.s.). High frequency transients reduced but transmitted acceleration still approx. 12 g. for same input.



"BARRYMOUNT" Isolator. Non-linear, air-damped. No snubbing at resonance (8 c.p.s.). Transmitted acceleration for slightly increased input (±0.030") is 0.62 g.

Nett Gain <1?

Where airborne application of instrumentation is concerned, it is all too easy to find "progress" has resulted in the substitution of one element of chance, not necessarily human, for another and the nett gain can actually be well below unity.

The new enemy is vibration. The more complex and sensitive the equipment, the more potent is the enemy, and protection against vibration becomes part of the design problem. Attempts to achieve isolation have often magnified the problem, for it is obvious that if a major component of the offending vibration happens to be at the resonant frequency of the isolator employed, danger is increased by the isolator itself.

To keep the resonant frequency of the isolator low is not a complete answer. In fact there is, as yet, *no* complete answer. But by far the nearest approach is today provided by "BARRYMOUNT" Isolators, the principle of which is the complementary performance of non-linear springing and *air-damping*. Even at resonance "BARRYMOUNT" Isolators offer quite spectacular freedom from vibration, as the accompanying un-retouched oscillographs of transmitted acceleration show.

We shall be happy to tell you all you want to know about "BARRYMOUNT" Isolators. We shall be even happier to mount your "problem unit", in your presence, and give it "the works".

Your equipment rides safely on the

MADE IN ENGLAND UNDER LICENCE
BARRY B MOUNT
FROM BARRY CONTROLS INC. OF U.S.A.

"BARRYMOUNT" and "BARRY B MOUNT" are Registered Trade Marks
CEMENTATION (MUFFELITE) LTD. 20 ALBERT EMBANKMENT, LONDON, S.E.11 TELEPHONE RELIANCE 6556

TRANSMITTING TETRODES

Type C.1112 has a maximum anode dissipation of 250W and is suitable for use as a power amplifier in transmitters up to 400W, as an oscillator, or in R.F. heating equipment (up to 1 kW per valve). ***Type C.1108*** is a smaller version designed for similar uses at lower power levels (anode dissipation 125W).

E.E.V. type	C.V. number	American equivalent	Max. operating frequency (Mc/s)
C.1108	2130	4-125A	200
C.1112	2131	4-250A	120

Full data relating to these valves will be sent on request

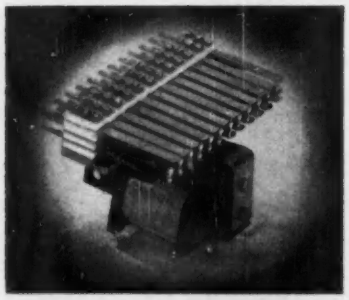
'ENGLISH ELECTRIC'

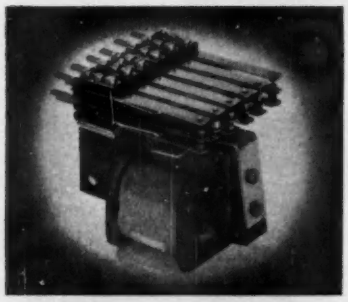
ENGLISH ELECTRIC VALVE CO. LTD.

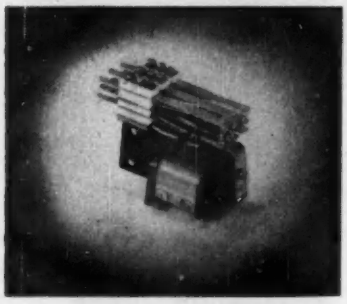
Chelmsford, England.
Telephone: Chelmsford 3491

AP300/48

A. C. RELAYS **SIEREX LTD** D. C. RELAYS







announce a new range of highest quality

RELAYS

up to :-

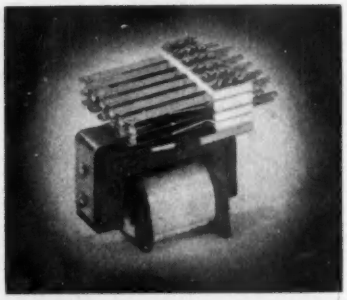
12 Changeover Contacts
Light Duty 1·5 Amps at 250 Volts.

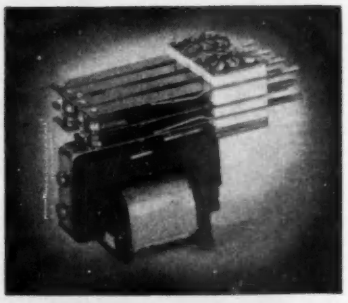
8 Changeover Contacts
Medium Duty 2·5 Amps at 250 Volts.

5 Changeover Contacts
Heavy Duty 5 Amps at 250 Volts.

15 Amp Contacts also available (Fully enclosed design)

Coils supplied for Standard Voltages 6, 12, 24, 125 and 220 Volts. Other Voltages on request.





* Solid Silver Contacts
* Moulded Spools
* Plastic Insulators.
* Constant Operate/Release Times
* Very Long Life
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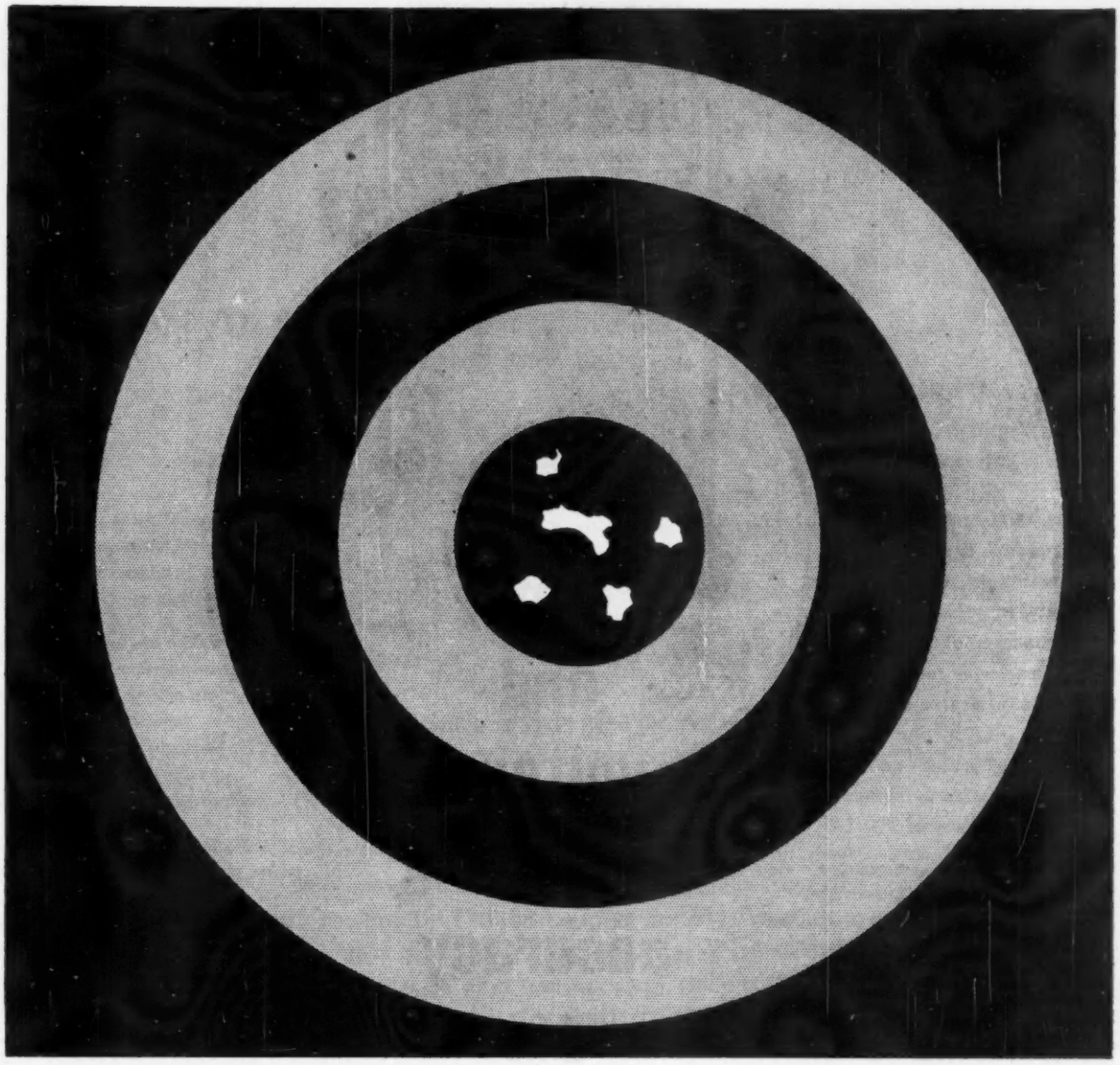
AGENTS FOR MAGNET-SCHULTZ MEMMINGEN

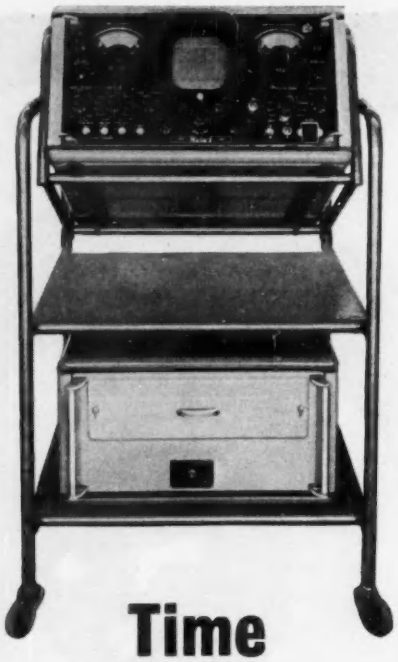


Metropolitan Plastics Limited

Very sharp shooting ..... forgive our enthusiasm, but working as we are to the highest standards of precision as a daily routine, we naturally have an interest in such things. If precision work (in thermo-setting plastics) is what you're looking for, plus the capacity to turn out a job bang on time, you'll be sure to find it with; Metropolitan Plastics Limited.

CERTIFIED ZINC ALLOY ZAMCA DIE CASTERS

Glenville Grove Deptford London SE8 Telephone: TIDeway 1172 *Specialists in Thermo-setting Plastics*



Time and voltage measuring accuracy 3%

MULLARD single beam Precision Oscilloscope type L.140 is an invaluable aid to engineers working in pulse circuitry, where the measurement of pulse amplitude and duration is required to an exceptional degree of accuracy. Unique circuitry and the use of large illuminated scales enables these quantities to be measured with an accuracy of 3%.

The "Y" amplifier, comprising a main and pre-amplifier, can be switched to provide both A.C. and D.C. coupling facilities, whilst a probe ensures that the circuit measured is not unduly loaded. The triggered time-base has a rapid start and exceptional linearity throughout its sweep.

When the oscilloscope is triggered by randomly spaced pulses, the leading edge can be clearly observed and measured with accuracy.

To preserve the high measuring accuracy, considerable attention has been paid to stabilising the separate power supply. Mains voltage fluctuations up to ± 7% do not affect the performance of the instrument.

Both the display unit and the power supply are normally supplied in metal cabinets, suitable for bench or trolley mounting. The front panel and chassis assemblies, however, have been so constructed that they will fit conveniently into a standard 19" rack.

ABRIDGED SPECIFICATION

TIME BASE

Triggered, free running, or synchronised.

Sweep duration	5μsec. to 150 msec. in 10 ranges.
Sweep length	Constant on all ranges, can be expanded up to 5 screen diameters.
Time measurement ranges	0–5 μsec., 0–15 μsec., 0–50 μsec., etc. to 150 msec.
Trigger input impedance	1MΩ + 25 pF, alternatively 10 MΩ + 10 pF.
"X" amplifier sensitivity	1.2V pk-pk/cm to 6V pk-pk/cm.
Bandwidth	1 c/s – 2 Mc/s (70% response)
Input impedance	1 MΩ + 30 pF.

'Y' AMPLIFIER

	Main Amplifier only	*With Pre-amplifier*
Maximum sensitivity	150 mV pk-pk/cm	4.5 mV pk-pk/cm
Maximum bandwidth	D.C. to 7.5 Mc/s (70% resp.) D.C. to 13 Mc/s (30% resp.)	1c/s to 6Mc/s (70% resp.) 0.7c/s to 10Mc/s (30% resp.)
Rise time	0.05 μsec.	0.06 μsec.

Input impedance	400–600 KΩ + 25 pF. (D.C. range)	400 KΩ + 45 pF. (A.C. range)
Voltage measurement ranges	0–30 mV, 0–100 mV, 0–300 mV, etc. to 0–300 V.	
Signal delay	0.6 μsec. (switchable).	

CATHODE RAY TUBE

Mullard type DG13-34/5ADP1, incorporating post deflection acceleration (switched)

Diameter	13 cm. masked to 9.4 cm square.
Screen	Blue-green medium persistence phosphor.

Mullard
SPECIALISED ELECTRONIC EQUIPMENT

Mullard

MULLARD LIMITED
MULLARD HOUSE
TORRINGTON PLACE
LONDON WC1
TEL: LANgham 6633

ME620

'FLUON'

Polytetrafluoroethylene

Polytetrafluoroethylene, renowned for its wide working temperature range of at least minus 80°C to + 250°C and its virtual immunity from chemical attack, is also the best of the solid dielectrics. It has a very low permittivity and power factor both of which are independent of frequency and temperature. It is also a good electrical insulator particularly so because it is non-tracking, is not wetted by water and does not absorb water. It is non-inflammable, has excellent weathering characteristics and its tough flexible nature is retained down to very low temperatures. It is also remarkable for its very low coefficient of friction and the fact that few materials will stick to it.

In addition to granular polymer 'Fluon' is now available as a paste polymer and as an aqueous dispersion. Paste polymer has been developed especially for extrusion and for the first time in this country the raw materials are now available to produce a complete range of covered wire, cables and sleevings to meet the needs of the electronic engineer. The general purpose dispersion can be used for casting film, of particular importance in the manufacture of high temperature condensers, for impregnation of glassfibre yarn, tape and fabric and for preparing filled moulding powders. Special dispersions are also available for spray coating of metals, glass, ceramics, and other surfaces to provide low friction, non-stick and non-wetting coatings.

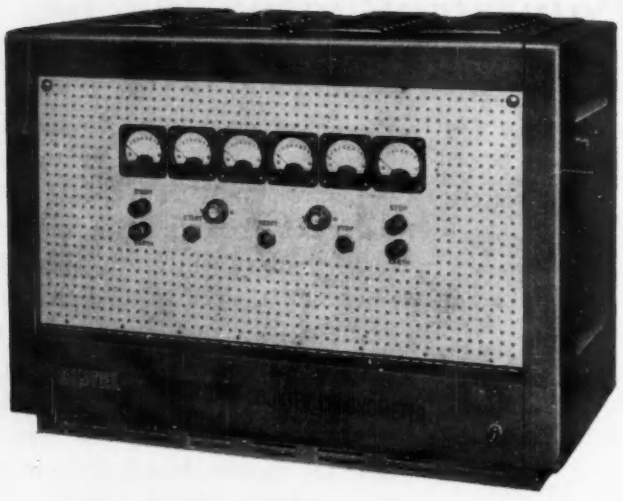
'FLUON'

'Fluon' is the registered trade mark for the polytetrafluoroethylene manufactured by I.C.I.

ICI IMPERIAL CHEMICAL INDUSTRIES LIMITED · LONDON · S.W.1.

PF.33

MICROSECOND CHRONOMETER



This equipment is designed to measure small intervals of time to a high order of accuracy and two ranges are provided:

(1) 1 μsec. to 1 sec. in steps of 1 μsec.

(2) 10 μsec. to 10 sec. in steps of 10 μsec.

Accuracy of each range is better than ± 0.005% ± the step interval.

Full details on this and other 'Cintel' Chronometers are available on request.

CINEMA TELEVISION LTD

A COMPANY WITHIN THE RANK ORGANISATION LIMITED

WORSLEY BRIDGE ROAD · LONDON · S.E.26
HITHER GREEN 4600

SALES AND SERVICING AGENTS:
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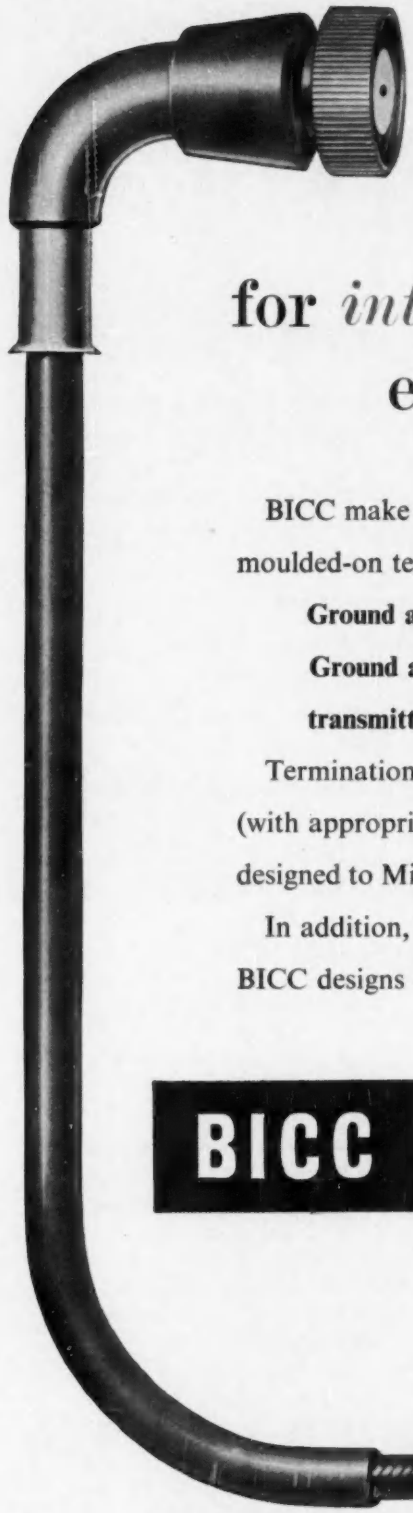
Atkins, Robertson & Whiteford Ltd., Industrial Estate, Thornliebank, Glasgow.
McKellen Automation Ltd., 122 Seymour Grove, Old Trafford, Manchester, 16



for *interconnecting* electronic equipment

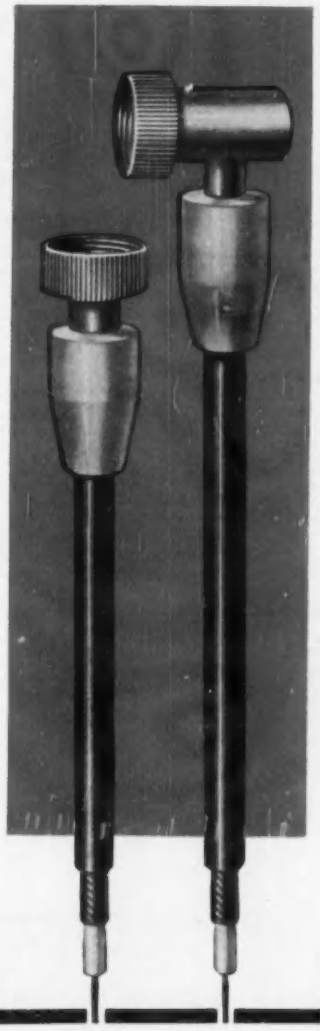
BICC make Coaxial Radio Frequency Connectors with moulded-on terminations for use with—

Ground and airborne radar equipment

Ground and airborne radio transmitters and receivers

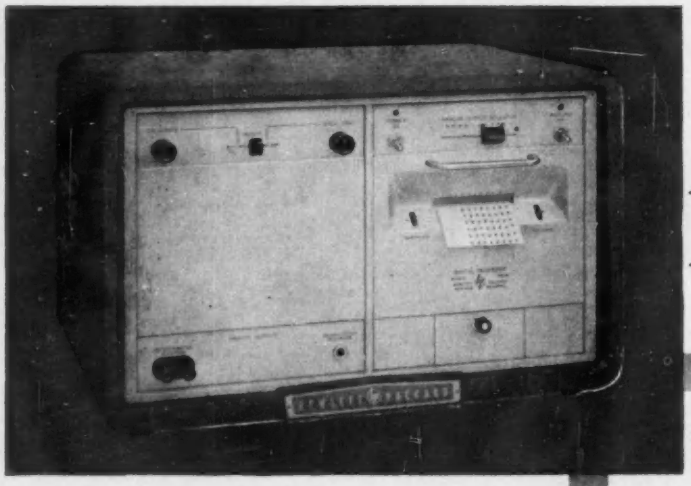
Terminations include a standard range (with appropriate panel mounting units) designed to Ministry of Supply requirements.

In addition, there are a number of BICC designs for other applications.



BICC *coaxial* **R.F. CONNECTORS**

BRITISH INSULATED CALLENDER'S CABLES LIMITED,
21 Bloomsbury Street, London, W.C.1



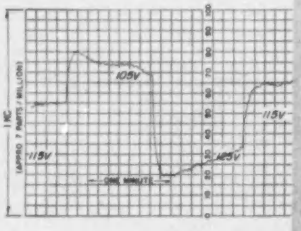
new -*hp*- 560A

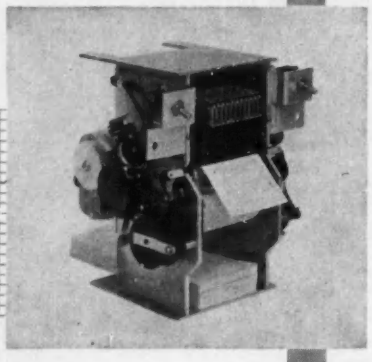
DIGITAL RECORDER

Continuous digital record for your frequency counter!

- **Prints 11-digit information at 5 lines per second**
- **Controlled by electronic or mechanical devices**
- **Direct print-out from all -*hp*- counters**
- **Analog output for strip-chart recorder**
- **Expanded scale; full scale can represent $1/10^7$**

Frequency stability vs. line voltage; 150 MC oscillator





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Print Command Signal: 1 μsec or greater, positive or negative pulse, 15 volts p-p or greater.
Paper Required: Standard 3" roll or folded paper.
Line Spacing: Single or double, adjustable.
Analog Signal: Any three consecutive digits may be selected by selector switch. Output is function of selected digits. For example, if consecutive digits were 3, 8, and 6, output voltage would be 38.6 millivolts or 0.386 ma.
Output Available: 1 milliamp for galvanometer strip-chart recorders. 100 millivolts for potentiometer strip-chart recorders.
Power: 105/125 volts, 60 cycles, 250 watts.
Dimensions: Cabinet Mount: 20½" wide, 12½" high, 18½" deep. (Rack Mount available).
Weight: Net 60 lbs. Shipping 100 lbs.
Accessories Available: 1052-24, 3" folded paper, 48/carton.
Price: Price on request.

Data subject to change without notice
Price f.o.b. factory

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Complete details from your -*hp*- representative, or write direct.

HEWLETT-PACKARD COMPANY
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GAYTHORN MILL, ALBION ST.,
MANCHESTER. 15.

R. M. PARRY
MANAGING DIRECTOR

TELEPHONE:
CENTRAL 1911

February, 1958

Fifty Years Young

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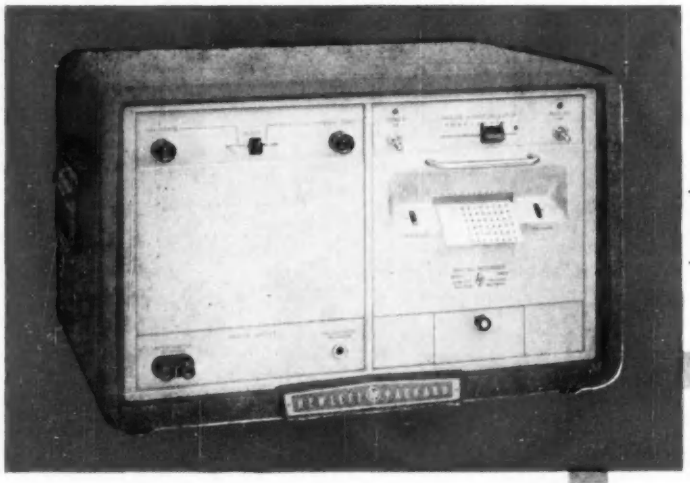
R. M. Parry

R. M. Parry
Managing Director

1908-1958
50 years



new -*hp*- 560A

DIGITAL RECORDER

Continuous digital record for your frequency counter!

- **Prints 11-digit information at 5 lines per second**
- **Controlled by electronic or mechanical devices**
- **Direct print-out from all -*hp*- counters**
- **Analog output for strip-chart recorder**
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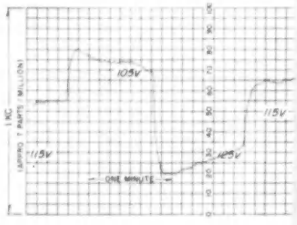

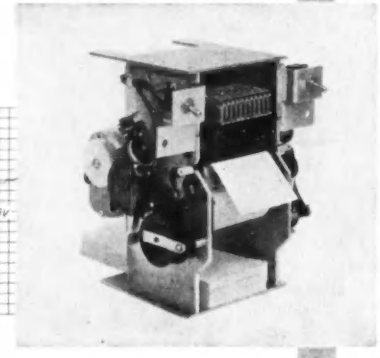

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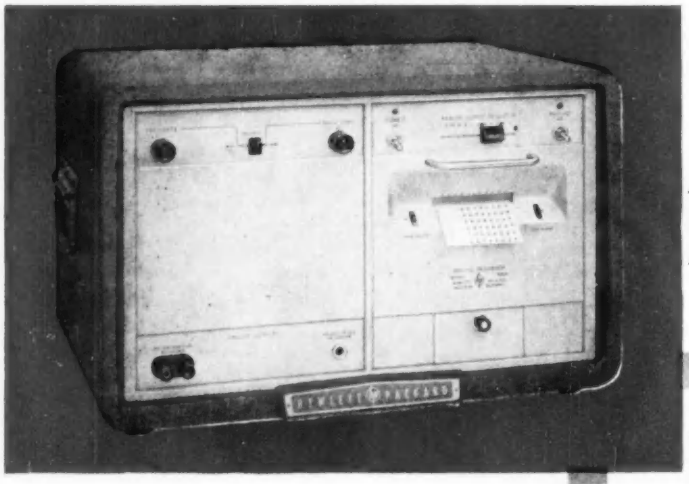

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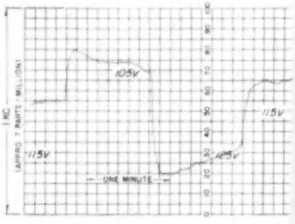

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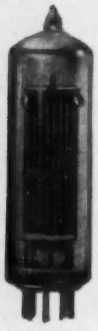
1908 1958
50 years

Mullard
INDUSTRIAL

20,000 times more sensitive than an ordinary photocell

A new type of photocell with an entirely new order of performance has been developed in the Mullard Solid State Physics Laboratories and is now about to go into production.



Employing a large area cadmium sulphide photosensitive element, the new cell provides a sensitivity approaching that of a photomultiplier . . . . *and* a current handling capacity of tens of milliamps.

Technical information is in the course of preparation and you are invited to use the coupon at the foot of the opposite page.

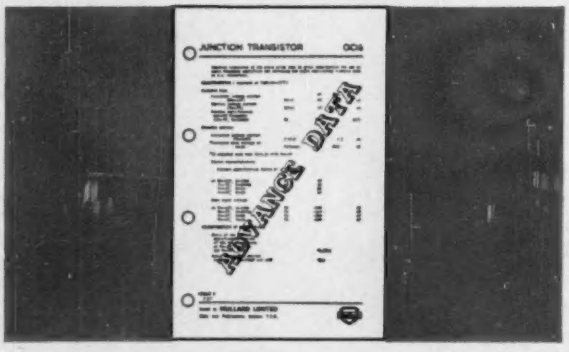
New Valve for 470 Mc/s Equipment

The six watt double tetrode QQV02–6 is designed for low cost 470 Mc/s mobile equipment. This compact valve features a frame grid and the same unique twin construction as other Mullard double tetrodes—a construction which provides higher efficiencies, high power gain and heater economy. Write for details of the QQV02–6 and other Mullard double tetrodes.

Transistor OC16 now available in quantity

Transistor OC16 is now available in quantity. This high output germanium junction transistor is being used to great advantage in audio frequency amplifiers and switching and pulse oscillating circuits such as d.c. converters.

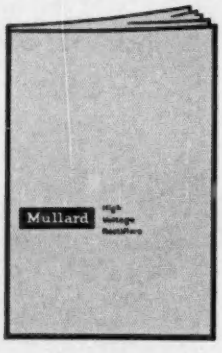
A pair of OC16's operating in Class B push-pull will provide an output in excess of 10 watts into loudspeakers with 12 volts "H.T.". Thirteen pages of data are available on the OC16. Please write or send coupon to the address at the foot of the opposite page.



Three New High Voltage Rectifiers

Recent developments in the Mullard 1.25 amp range of xenon rectifiers have led to improved hold-off characteristics and higher reliability. These improvements, together with the already widely recognised advantages of xenon rectifiers, strongly recommend these valves for power supplies in transmitters, r.f. heaters and similar equipments.

Full details of these three rectifiers, the RR3–1250, the RR3–1250A and RR3–1250B, together with information on other xenon and mercury vapour rectifiers are given in the free data booklet "High Voltage Rectifiers" offered in the accompanying coupon.



Mullard

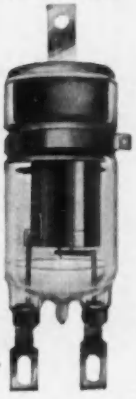
VALVE NEWS

Six C.R.T.'s that cover most instrument applications

Designers faced with the problem of selecting instrument cathode ray tubes are finding it quicker and easier to check against the Mullard range first. The compact but comprehensive range of six tubes fulfils 85% of all practical requirements. Refer to the foot of this page for free data booklet which gives details of these six and other tubes made by Mullard.

New Heavy Duty Thyratrons

The two new heavy duty thyratrons, XR1–6400A/6807 and XR1–12/5855, embody a new type of construction which provides improved mechanical and electrical performance.



The XR1–12 will continuously control currents of up to 12 amps, while the maximum current rating of the XR1–6400A is 6.4 amps. These two valves are rugged and their long life is backed by a year's guarantee. Their heating-up time is only one minute, and they will operate over a wide range of ambient temperatures.

Post the coupon below for data on both types.

Question and Answer Mullard technical personnel will be present at the following exhibitions to give all possible assistance to visitors in the selection and operation of Mullard products. Valves, tubes and semiconductors will be shown at all exhibitions with the exception of the R.E.C.M.F. where Mullard are showing semiconductors only.

PHYSICAL SOCIETY EXHIBITION
Horticultural Hall, 24th–27th March. Stand Nos. 104 & 115
R.E.C.M.F. EXHIBITION, Grosvenor House, 14th–17th April. Stand No. 21
MULLARD HOUSE EXHIBITION, Torrington Place, 14th–18th April
INSTRUMENTS, ELECTRONICS & AUTOMATION EXHIBITION
Olympia, 16th–25th April. Stand No. 501

Mullard

COMMUNICATIONS AND INDUSTRIAL VALVE DEPARTMENT

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Tick where applicable

- ☐ Cadmium Sulphide Photocells
- ☐ Double Tetrode QQV02-6
- ☐ Transistor OC16
- ☐ High Voltage Rectifiers
- ☐ Instrument Cathode Ray Tubes
- ☐ Heavy Duty Thyratrons

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DEPARTMENT _____

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who demands
'immediate reaction'

SUPER HIPERM

When 'immediate reaction' is of vital importance, knowledgeable technicians specify Super Hiperm produced by Low Moor Alloy Steelworks Ltd. Triple refined to give magnetic properties of outstanding performance and superior in high permeability, Super Hiperm is supplied as ingots, billets, slabs, plates, regular bars and special forms. For full details of application and magnetisation curve, get in touch with Low Moor Alloy Steelworks Ltd.

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LMAS/PPPS/HP2

Fielden AUTOMATION

Servograph MKII

The Fielden Servograph Electronic Recorder for accurate micro-amp recording.

The ideal Recorder for use with

SMOKE DENSITY METERS

CO_2 INDICATORS

pH METERS

ISOTOPE THICKNESS GAUGES AND LEVEL INDICATORS

TACHOMETERS ETC.

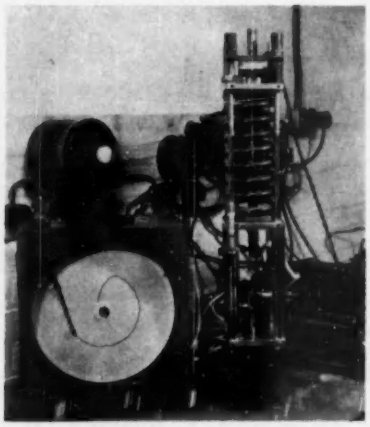
The Servograph can be supplied with Full Scale Deflection for 50 microamps D.C. It can directly replace any moving coil meter in almost any circuit and is used by many of the major manufacturers of indicating instruments for providing a permanent record.
Difficulties normally associated with light current electrical recorders are eliminated by the capacity servo system and the motor operated pen mechanism has ample power for operating electrical or pneumatic controllers which can be fitted.

Accuracy—1%
Speed of Response—
Zero to full scale in 5 secs.
Minimum Ranges—
0-50 microamps dc.
0-30 millivolts dc.

Four Point Recorder

The Servograph can be supplied to record four different quantities on the same chart in different colours at a cost of approximately £40 per point.

The photograph shows Fielden Smoke Density Servographs installed at St. Pancras Power Station.



The creep test loader by Aero Research Ltd. incorporates the Fielden Servograph.

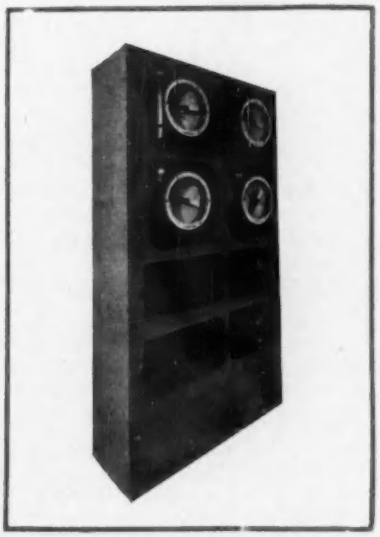


Illustration shows a typical panel installation and complete panels can be supplied for any application.

Fielden

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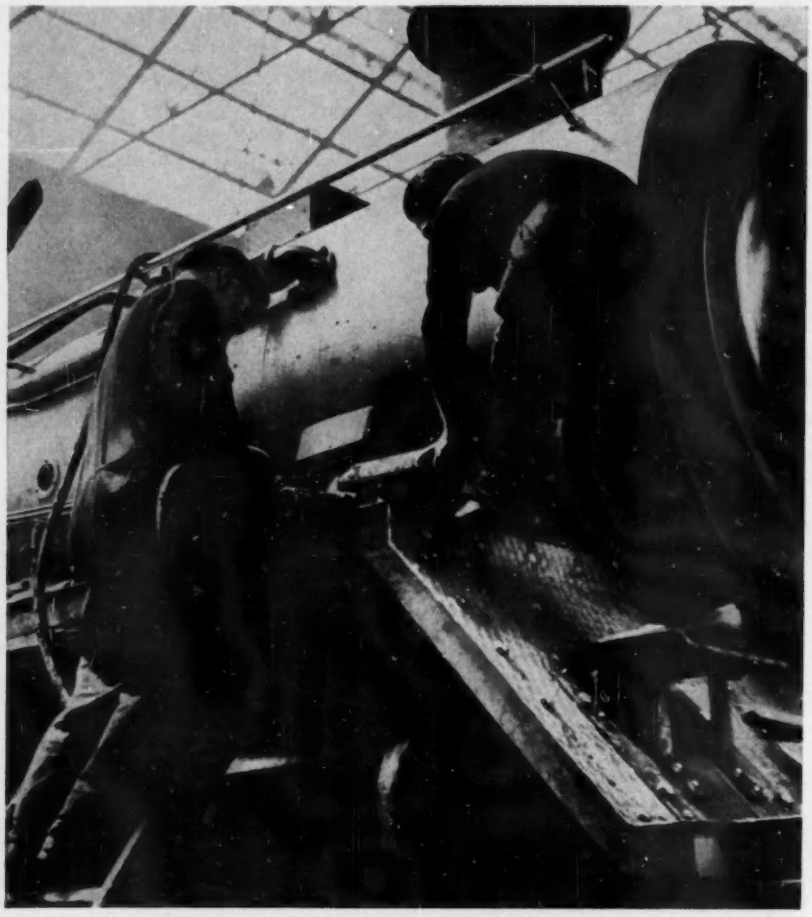
C.M.A. Cables at work



Building a locomotive. Here the operator is drilling platform plates at the smokebox end.

In the locomotive engineering works of the Midlands, in factories all over the country, at home or abroad, wherever you go C.M.A. cables are at work. In the air, underground or underwater, in ships, coalmines and powerhouses, C.M.A. cables are transmitting power, unobtrusively . . . reliably . . . year in year out. For over 100 years members of the Cable Makers Association have been concerned in all major advances in cable making. Together, member firms of C.M.A. spend over one million pounds a year on research and development. At every stage from raw material to finished cable, technical knowledge is pooled and research co-ordinated to avoid wasted effort. This highly-organized co-operative research activity has contributed largely to the world-wide prestige that C.M.A. cables enjoy. It has put Britain at the head of the world's cable exporters. Technical information and advice is freely available from any C.M.A. member.

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CMA 17

These screws are made from

Made in Nylon A100 material, these new screws will ease a great many production problems in electronic and electrical engineering. They have an extremely high abrasion resistance and a dielectric strength of 140-160 kV/cm at 25 degrees C.

Full technical information freely available on request.

made specially for scientists by GKN

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HEAT-STABLE, WATER-REPELLENT

MS SILICONE Dielectric materials

DIELECTRIC COMPOUND

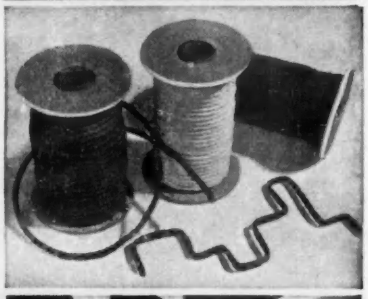
MS 4 compound is a non-melting, water-repellent paste which retains its grease-like consistency from −50°C to 200°C. It is highly resistant to oxidation and deterioration caused by corona discharge. Power factor is less than 0.001 up to 10 Mc/s; volume resistivity is more than 10^{12} ohm cm up to 200°C. Electric strength is more than 500 volts/mil at a 10 mil gap.

USES: Potting and sealing compound for electronic components, disconnectable plugs and sockets. Lubricant and protective agent for plastic and rubber cables, grommets and seals. Damping medium in gramophone pick-ups.

NEW FLEXIBLE SLEEVING

Braided glass sleeving is now available coated with Silastomer* silicone rubber. It is based on Fibreglass E glass yarn and is supplied in various colours and in continuous lengths. This flexible sleeving retains its good dielectric properties and tear resistance from −55°C to +250°C.

Manufactured by Jones, Stroud & Co. Ltd.



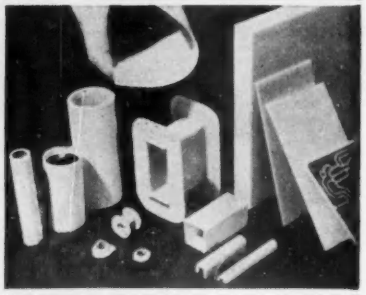
MS SILICONE RESIN-BONDED GLASSCLOTH LAMINATES

These laminates, with a heat stability permitting their use up to 250°C, have the following typical properties (tests according to BS.1137):—

Specific Gravity	**1.9**	**Power Factor at 10^6 c/s**	**0.001—0.003**
Tensile Strength, lb./sq. in.	**15,000-40,000**	**Permittivity at 10^6 c/s**	**3.9**
Flexural Strength, lb./sq. in.	**20,000-50,000**	**Electric Strength,**	
Water Absorption, %	**0.1**	**¼ in. thick, v/mil.**	**200-250**

The following is a quotation from the U.S. Navy Specification (MIL-E-16400 A Ships) governing naval ship and shore electronic equipment—"Where laminated thermosetting plastic sheets are used for insulation, silicone resin, glasscloth . . . is the preferred material. The use of this material is mandatory in critical circuits of equipments where maintenance of high circuit impedances (above 1 megohm) is required and in equipments where temperatures greater than 110°C are experienced in the areas where these parts are used."

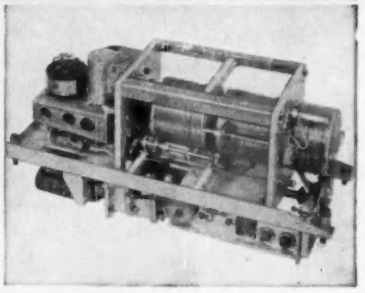
Ask for SILICONE NOTES L18—Properties and applications of silicone-bonded laminates.



Silicone laminate, being readily machinable, lighter and less fragile, has many advantages over ceramics for coil formers.

Aircraft high frequency communication equipment showing coil formers of silicone/glasscloth laminate.

By courtesy of Micanite & Insulators Co. Ltd. and Standard Telephones and Cables Ltd.



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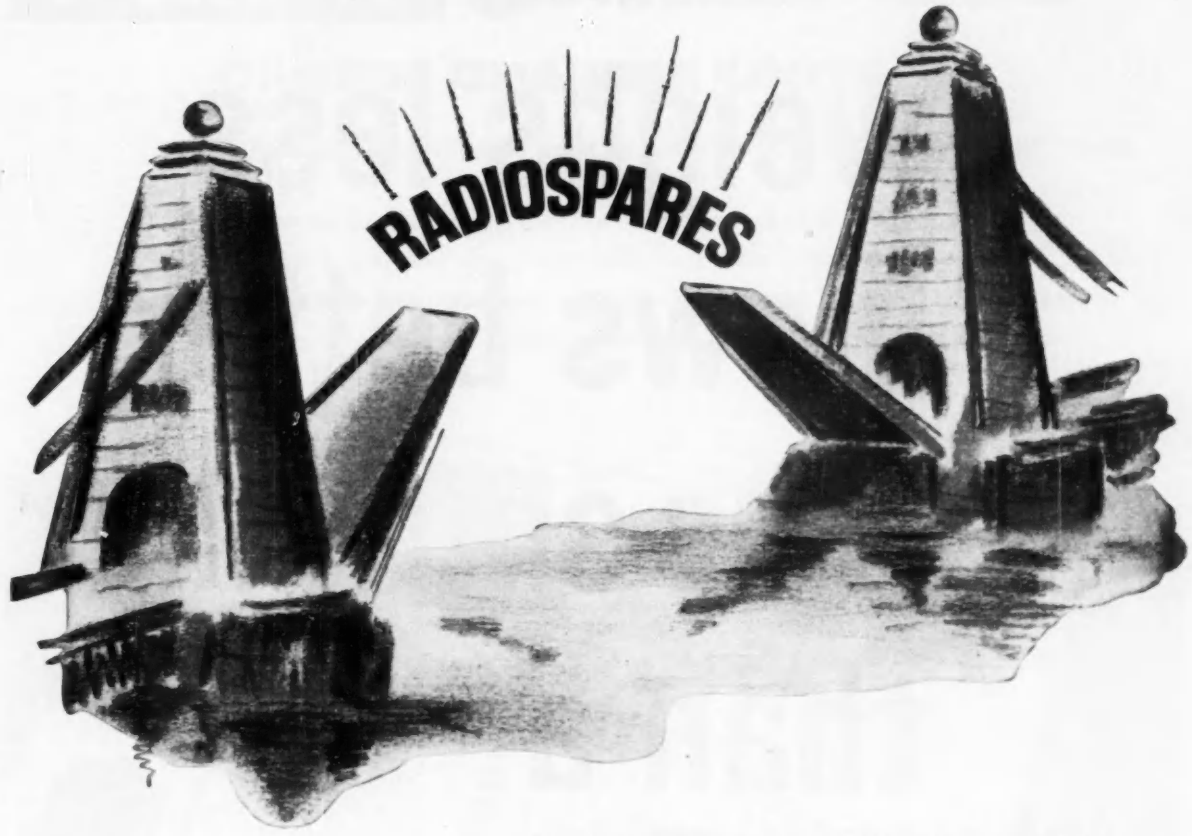

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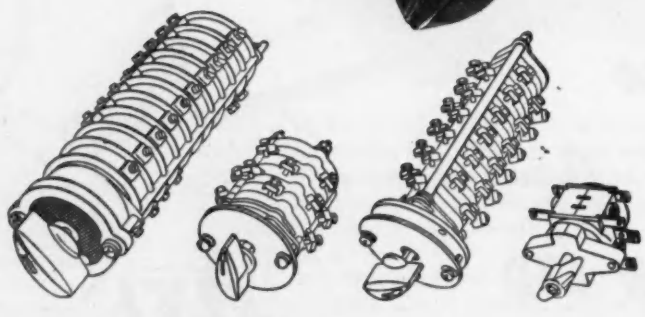
joins the *Austinlite* rotary switches

This new switch is identical in principle to the well established A50 and A30 rotary switches. It has the same rolling, self-cleaning contacts with extended horns to keep any arcing away from the contact faces — a feature exclusive to Austinlite rotary switches. It has a similarly powerful and positive switch mechanism, and can be built in the same variety of forms to switch in sequence or simultaneously very large numbers of circuits. It is extremely compact, the smallest of the Austinlite multi-cell rotary switches. It bridges the gap between the A30 and the little single-cell 10-amp switch. Delivery, on standard applications, can now be made in four weeks.

Our brochure "SIMPLIFIED SWITCHING" will tell you more about the advantages of Austinlite Rotary Switches. May we send you a copy?



The four Austinlite Rotary Switches — A50, A30, A15 and A10.

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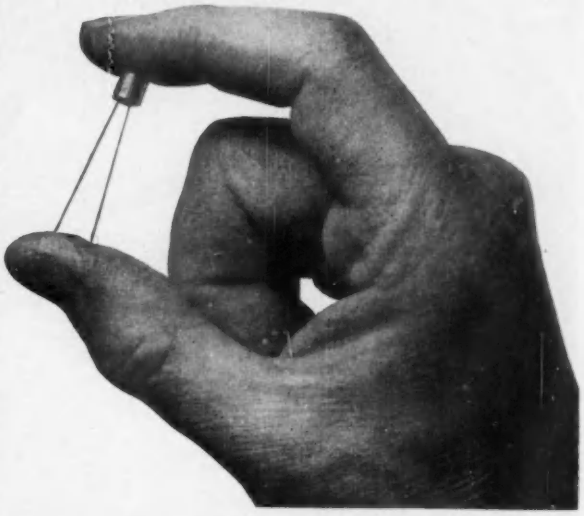

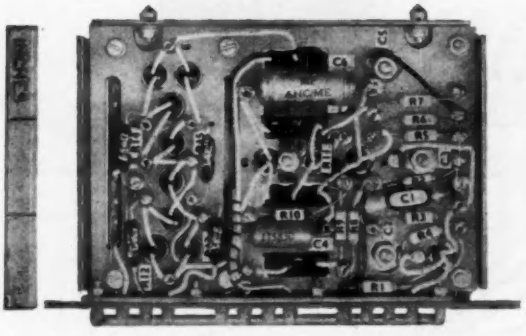

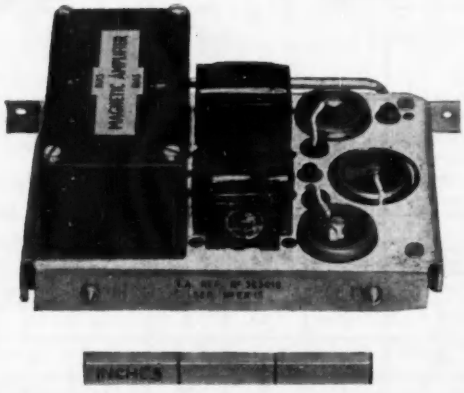

A wide range of applications

Ferranti Silicon Rectifiers are used in Magnetic Amplifiers made by Elliott Bros. (London) Ltd. They were chosen not only for their efficient operation, but also for their complete reliability, robust construction, small size and lightness in weight. Ferranti Silicon Rectifiers have many applications in the aircraft, electronic, electrical and general engineering industries including aero engine controls, aircraft power supplies, radar systems, guided missiles, computers, indicating and recording instruments, process control and telephone equipment.

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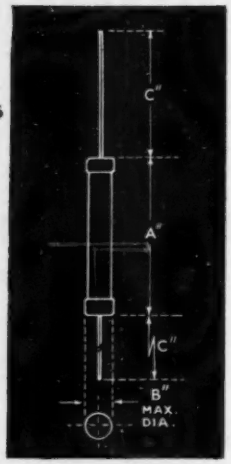
By Appointment to the Professional Engineer

HIGH STABILITY CARBON RESISTORS



ELECTRICAL CHARACTERISTICS

The electrical characteristic of a High Stability Carbon Resistor depends upon the physical size of the units and upon the ohmic value. All the data given below relates to the Type 73 Resistor. To obtain the equivalent ohmic values to which the information is applicable in the other four sizes of Resistor the following factors should be applied :

Type 72 x ½ Type 74 x 2 Type 75 x 4 Type 76 x 8

FULL LOAD STABILITY

Up to 100 K.ohms the resistance change at full load with an ambient temperature of 70°C. is less than 0·75% (average 0·25%) after 1,000 hours operation. At 1 Megohm the change is less than 1% (average 0·75%).

N.B. On D.C. loading the maximum voltages stated in RCL 112 should be observed.

AGEING AND SHELF DRIFT.

Up to 100 K.ohms the average change is 0·25% in 12 months (never greater than 0·75%). For 1 Megohm resistors the average change is 0·6% in 12 months (never greater than 1·25%).

CLIMATIC

Exposure to the two cycles of H.I. humidity as laid down in RCS 112 shows a change of less than 0·7% (average 0·4%) up to 100 K.ohms. At 1 Megohm the change is less than 1% (average 0·7%).

TROPICAL EXPOSURE

Eighty-four days exposure to the standard 25°C./35°C. 100% humidity cycling shows a change of less than 1% (average 0·5%) up to 100 K.ohms. At 1 Megohm the change is less than 2% (average 1·6%).

TEMPERATURE COEFFICIENT

The temperature coefficient is less than 0·04%/°C. up to 100 K.ohms. At 1 Megohm the coefficient is approximately 0·055%/°C.

NOISE

Noise which is generated in a resistor, as the result of a direct voltage applied across it, varies according to the ohmic value of the resistor, the noise decreasing as the ohmic value increases. The noise is also influenced by factors such as the size of the resistor.

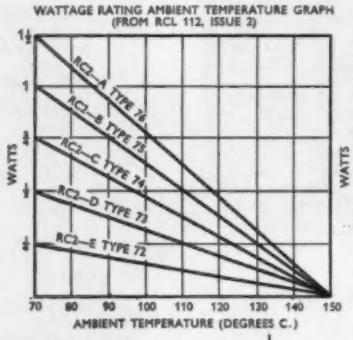
For noise which falls within frequency range of 0 to 10 Kc./sec., the Painton high stability resistors have noise levels which are between 0·05 and 0·4 microvolts of noise per applied direct volt, when the resistor is dissipating power at its maximum wattage rating.

VOLTAGE COEFFICIENT

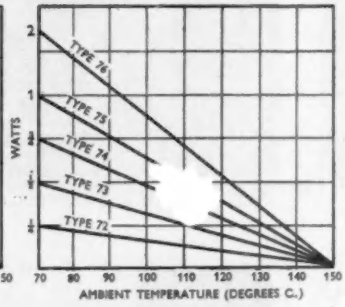
Not exceeding 0·002% per volt D.C.

DERATING FOR AMBIENT TEMPERATURES EXCEEDING 70°C.

WATTAGE RATING AMBIENT TEMPERATURE GRAPH (FROM RCL 112, ISSUE 2)



COMMERCIAL DERATING CURVE

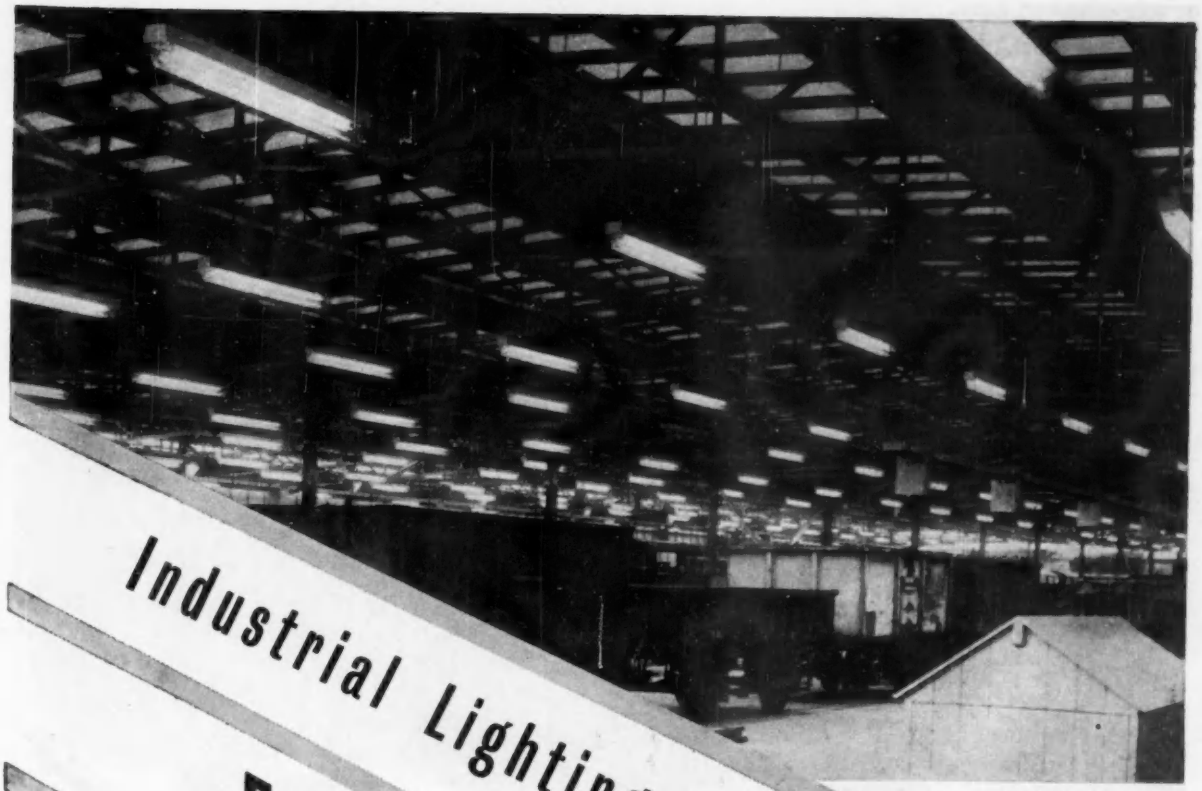


TYPE	RESISTANCE RANGE (ohms)	VALUES OUTSIDE THIS RANGE MAY BE QUOTED FOR SEPARATELY.	
72	±1% 4 — 700K	±2% 4 — 1·0M	±5% 4 — 2·5M
73	±1% 4 — 1·0M	±2% 4 — 2·0M	±5% 4 — 5·0M
74	±1% 20 — 2·0M	±2% 20 — 4·0M	±5% 20 — 10·0M
75	±1% 20 — 3·0M	±2% 20 — 5·0M	±5% 20 — 10·0M
76	±1% 20 — 5·5M	±2% 20 — 9·0M	±5% 20 — 50·0M

TYPE		72	73	74	75	76
Normal Commercial Rating 70°C—watts		¼	½	¾	1	2
R.C.S.C. style		RC2-E	RC2-D	RC2-C	RC2-B	RC2-A
R.C.S.C. Rating at 70°C—watts		¼	½	¾	1	1½
R.C.S.C. Rating at 100°C—watts		⅛	¼	½	¾	1
DIMENSIONS IN INCHES	A	¼	⅜	1 1/16	1⅜	2 1/16
	B	1/16	1/16	1/16	1/16	1/16
	C	1⅛	1⅛	1⅛	1⅛	1⅛

PAINTON

Northampton England



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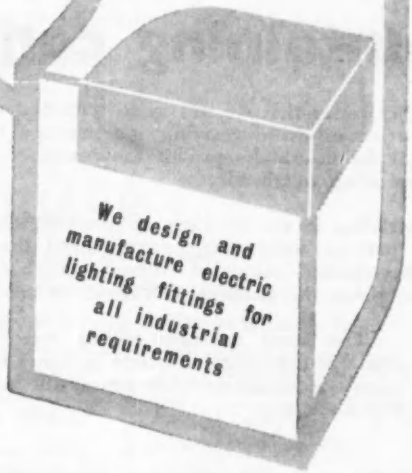

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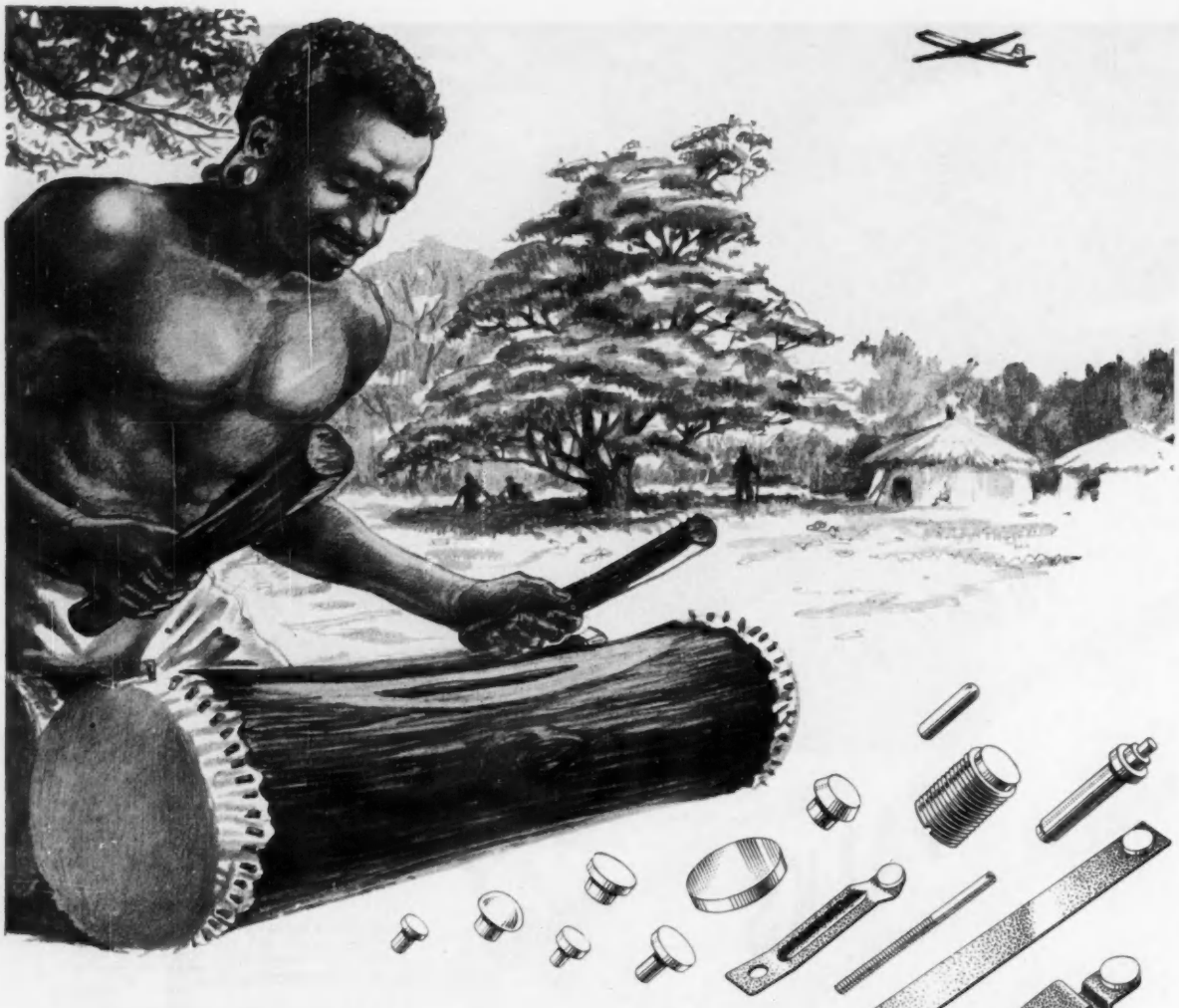

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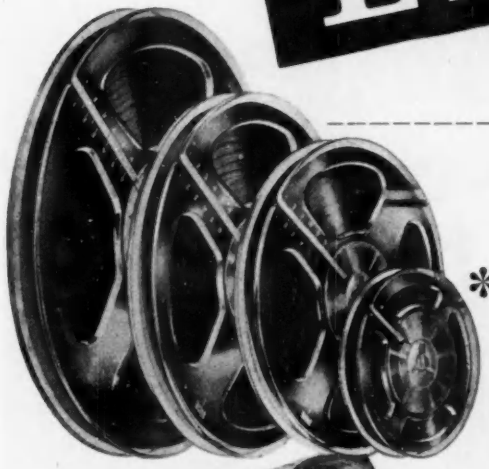

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★99/9E	"	5" dia.	850′	£1 . 10 . 6	£1 . 8 . 0
88/9E	"Continental"	5¾" dia.	850′	£1 . 10 . 6	£1 . 8 . 0
★99/12E	"	5¾" dia.	1200′	£1 . 17 . 6	£1 . 15 . 0
88/12E	"Standard"	7" dia.	1200′	£1 . 17 . 6	£1 . 15 . 0
★99/18E	"	7" dia.	1800′	£2 . 12 . 6	£2 . 10 . 0
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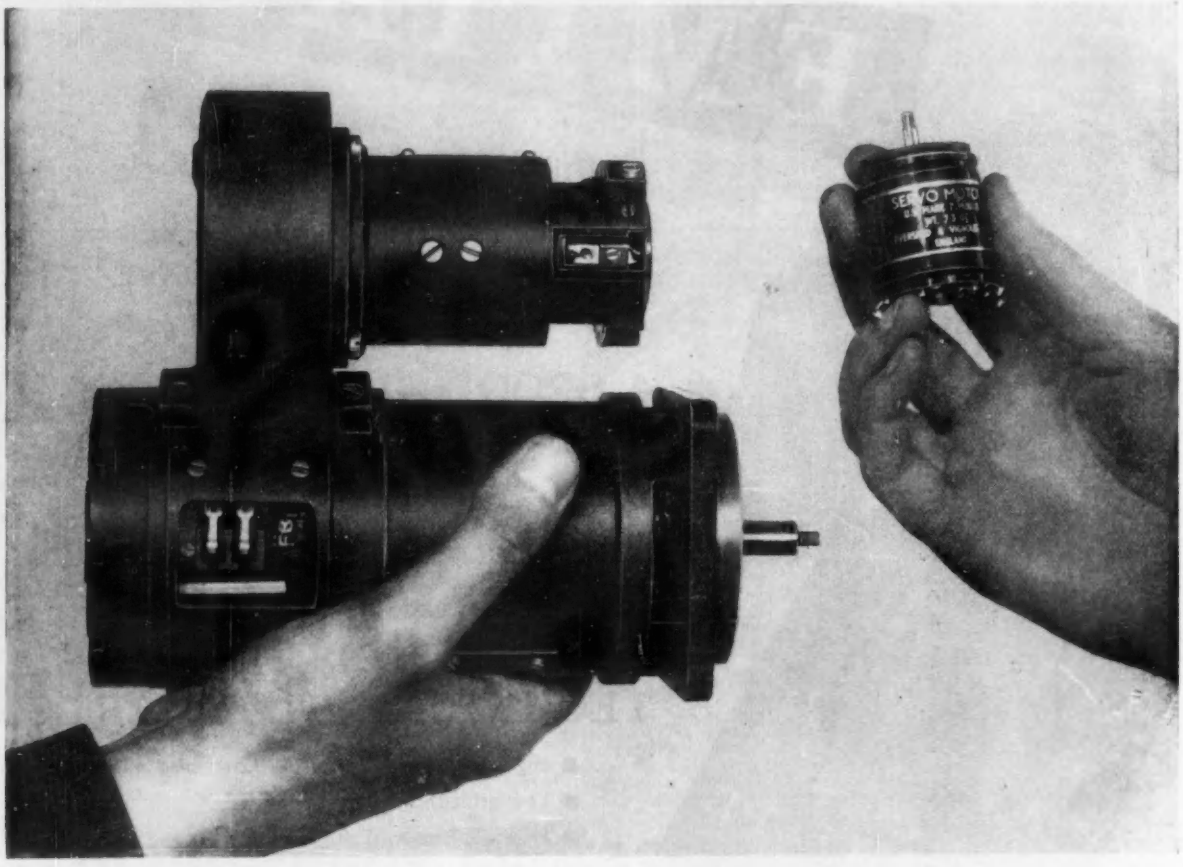

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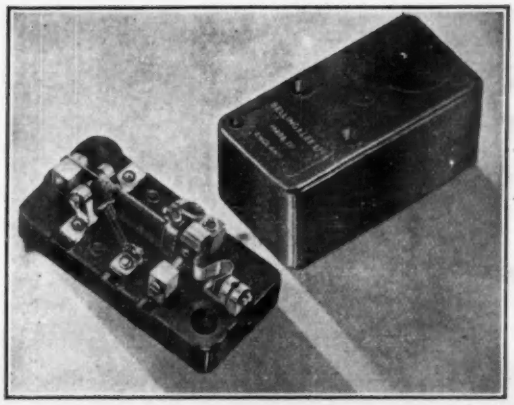


L.413
DELAY SWITCH
auto-resetting

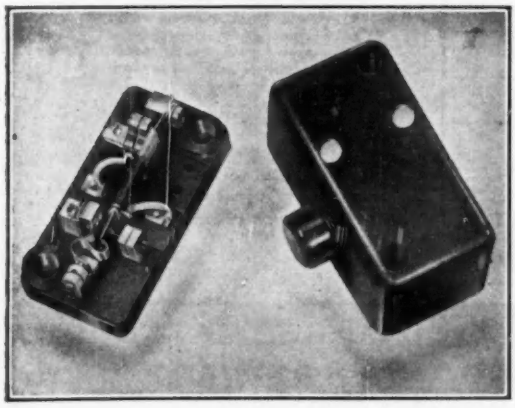
"BELLING-LEE"
Thermal Switches

These current-operated, bi-metal switches are designed for circuit protection and to control circuits requiring a particular time lag of operation. They are rated up to 5 amp. with contact voltages up to 250 volts A.C. They will trip currents of up to 20 amp. at 250 volts A.C., 5 amp. at 50 volts D.C., 2.5 amp. at 100 volts D.C. and 100 mA at 250 volts D.C.

L.415 is the hand resetting version. It is for use in circuits which should be remade at the discretion of the operator.

Normally open, normally closed or changeover contacts are available and the switches can be calibrated to individual requirements to a maximum time delay of 30-60 secs. Auxiliary contacts can be fitted to L.413 to "make" or "break" with main contacts. For L.415 these can be used for the "break" operation only. These switches are available with series, parallel or independent heaters rated up to 48 volts maximum.

Special thermal switches can be designed and manufactured to specific requirements where warranted.

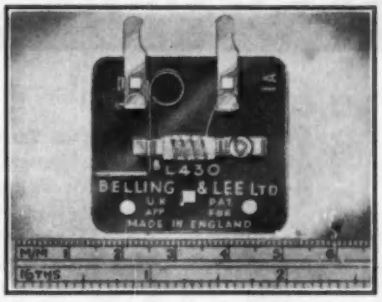


L.415
DELAY SWITCH
hand-resetting

"MINITRIP"
L.430 & L.430B

This simple, resettable cutout, designed primarily for overload protection in radio and television receivers has an almost infinite number of applications in the electrical and electronics fields, (e.g. small power tools, computer circuit protection, protection of automation equipment, etc.) It is especially valuable in cases where fire and safety regulations demand protection against harmless small overloads, and a traditional wire fuse sufficiently closely rated will not withstand normal switching surges.

The surge resistance is such that an overload of 40 times rated current for 0.02 seconds does not cause tripping, damage, or an alteration in characteristics.



Should a short-circuit produce an abnormally large sustained overload it is possible for the "Minitrip" to be destroyed, but protection is still given.

A "Minitrip" is cheaper than a fuse and fuseholder, and provides better protection characteristics.

RATINGS

100, 150, 200, 250, 300, 500 and 750 milliamperes, and 1 ampere.

Other ratings can be supplied to order up to 2 amperes.

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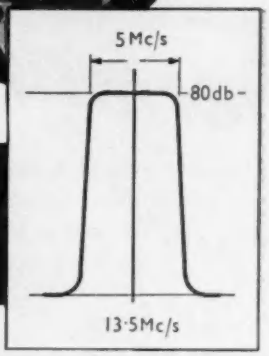
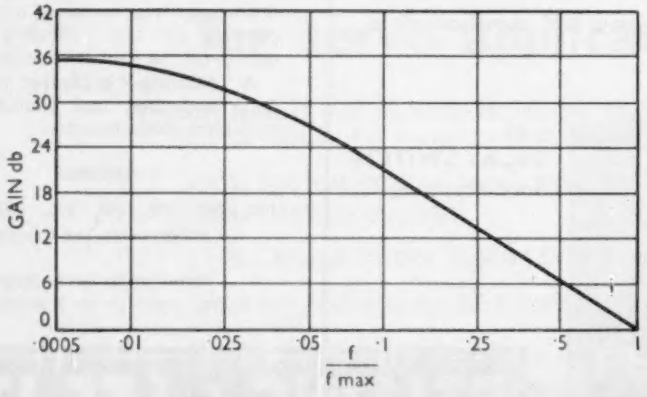
Decca Radar Research Laboratories



Semiconductors
TRANSISTORS for above 5 Mc/s

Semiconductors Surface Barrier transistors at last give British engineers the opportunity to design transistors into high frequency circuits requiring real performance above 5 Mc/s. They can be used as RF, IF and video amplifiers in communication, radar and navigational equipment. The illustration shows an extremely compact 13.5 Mc/s. IF amplifier developed by Decca Radar Research Laboratories using SB103 type transistors and consuming less than 50 milliwatts.

In video amplifier circuits, the SB103 has a gain-bandwidth product of 60 Mc/s and the equivalent figure for the 2N300 is over 100 Mc/s. In neutralised common-emitter circuits, the SB103 gives a power gain of 20dB at 5 Mc/s and 15dB at 10 Mc/s. The 2N299 gives 20dB at 10 Mc/s and 10dB as high as 30 Mc/s.



The curve shows power gain plotted against frequency for Surface Barrier Transistors.

Full technical data and application notes are available on these and any other Semiconductors transistors. Engineers and senior executives are invited to write for copies. Assistance with design problems is freely available.

Production of Semiconductors transistors will commence in mid-1958. Sample quantities are available now.

Semiconductors Limited

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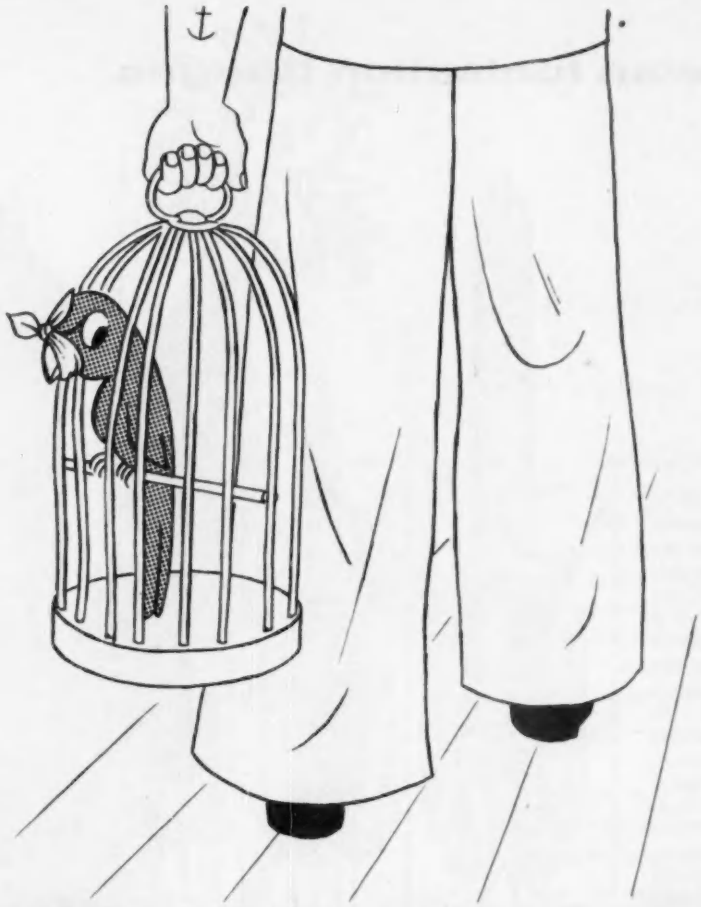

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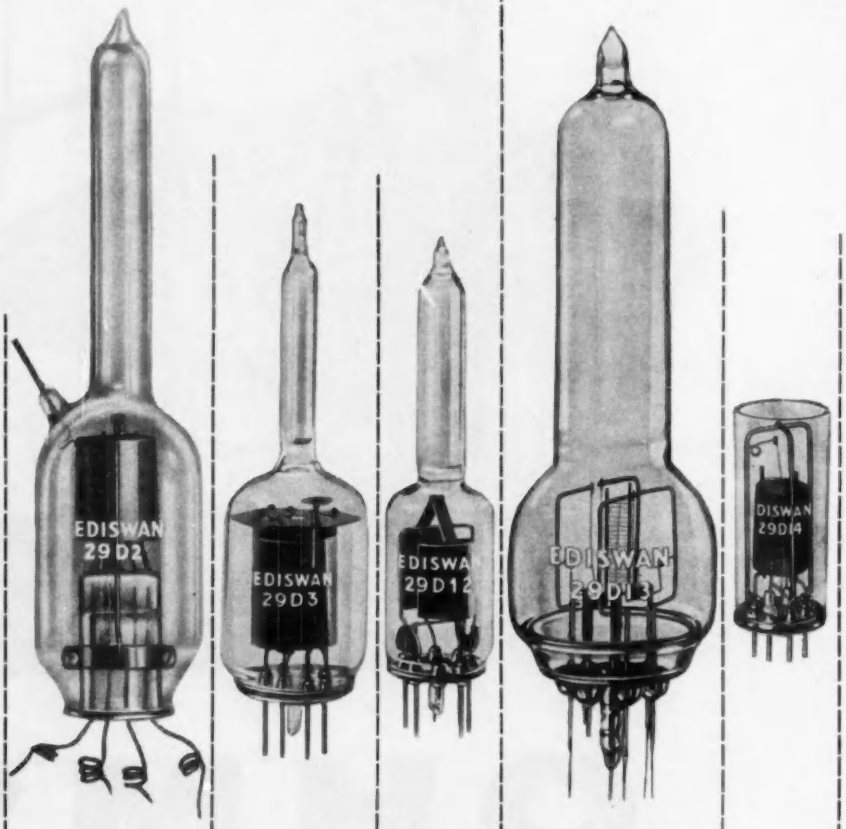


	29D2	29D3	29D12	29D13	29D14
Type of Gauge and Envelope	Hard glass	Soft glass	Penning—soft glass	Alpert—hard glass	Miniature—soft glass
Connection	Flying leads	Stiff wire	Stiff wire	Flying leads	Stiff wire
Approx. Sensitivity μA/mA/micron	20	20	(1mA at 10^{-5}mm)	9·4	4·5
Approx. Range	10^{-4}—10^{-7}mm	10^{-4}—10^{-7}mm	10^{-3}—10^{-8}mm	10^{-4}—10^{-10}mm	10^{-4}—10^{-7}mm
Notes		Double Filament			Rubber O-Ring Seal

SIEMENS EDISON SWAN LIMITED

An A.E.I. Company

Industrial Valves Division
155 Charing Cross Road, London W.C.2 and branches
Telephone GERrard 8660 · Telegrams: Sieswan, Westcent, London

CRC 16/3

Something to crow about!

. . . from morning till night the Brayhead Valveholders are something which really make us justifiably proud. Many types have been designed to suit all needs, and with printed circuits in mind they have proved completely versatile and competitive in price without falling from the very highest level of efficiency. These are some of the features which put the B9A Valveholder way out in front.

- Free-seating contacts (prevents damage to valves).
- Removable and replaceable contacts (no chance of solder running into contacts).
- Contact soldering to chassis if required.
- Wedge and spring locking action of can to saddle (no 'rock' or earthing noise).

With body moulded in ceramic or phenolic material with extremely low-loss properties and screening cans in all standard sizes and finishes, the Brayhead B9A Valveholders are unsurpassed in design and construction.

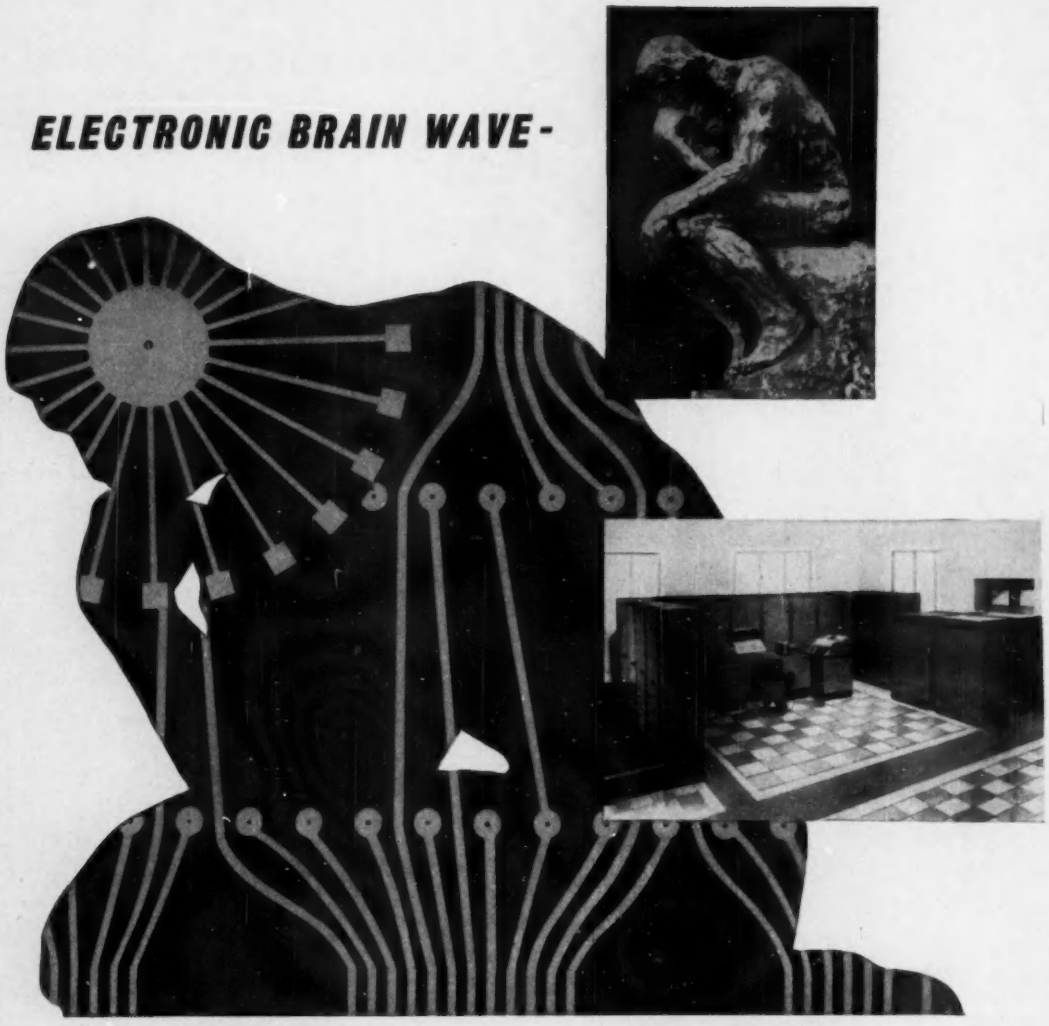
Write for full details and descriptive leaflet

BRAYHEAD (ASCOT) LTD.

FULL VIEW WORKS · KENNEL RIDE · ASCOT · BERKS · Tel: Winkfield Row 427/8/9, Ascot 1907/8 and 437 · Grams: Brayhead Ascot

B 34

ELECTRONIC BRAIN WAVE-



with BAKELITE Copper-Clad Laminated

REGD. TRADE MARK.

The Ferranti Mercury Computer, an immensely powerful machine of enormous capacity, is exceptionally fast and provides facilities for the most advanced techniques of programming. Among many interesting features of this machine is the use of printed circuits produced from BAKELITE Copper-Clad Laminated Materials. Used in front to back inter-connected panels and for mounting special pieces of equipment in various parts of the Computer, they reduce the bulk of these assemblies, thus helping to keep down the overall size of the Computer. Reliability provided by printed circuits is of prime importance and their use eliminates the possibility of faulty wiring, thus making servicing and maintenance very much simpler.

Today printed circuits on BAKELITE Copper-Clad Laminated Materials, either rigid or flexible, are finding new applications throughout the Radio and Electronics industries. They allow more freedom and precision to the designer, reduce production time and costs for the manufacturer, and give the customer a lighter, more compact and reliable instrument.

Write today for a copy of "Copper-Clad BAKELITE Laminated for Printed Circuits".

BAKELITE LIMITED

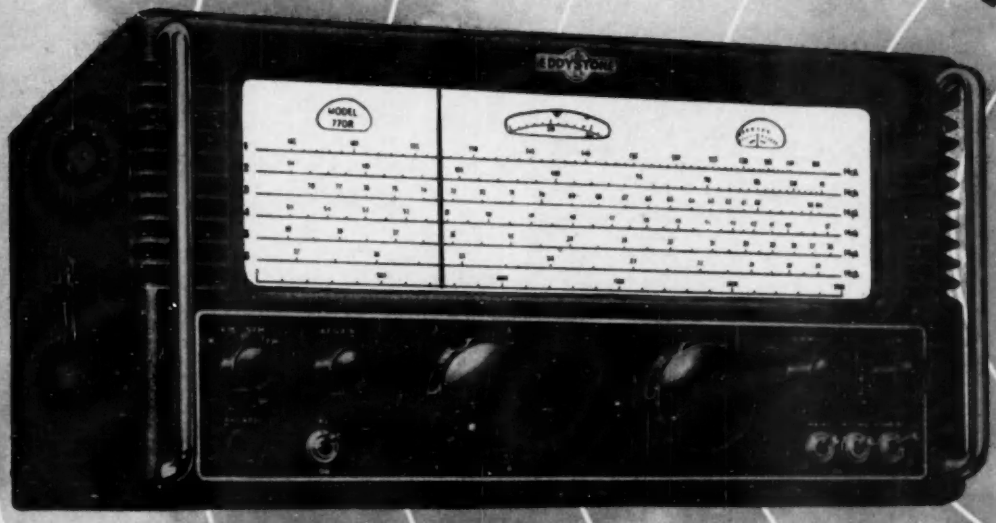
REGD.

12-18 GROSVENOR GARDENS · LONDON SW1 · SLOane 0898

Bakelite Limited manufacture an extensive range of plastics materials and maintain a technical service unequalled in the industry. No matter what your plastics problems this service is at your disposal. SLOane 0898 is the telephone number.

TGA 1/58A

technical achievement . . .



RADIO PRODUCTS
EDDYSTONE
TRADE MARK

EDDYSTONE VHF & UHF (AM & FM) Communications Receivers

Model 770R.
19-165 Mc/s.

Model 770U.
150-500 Mc/s.

Please write for full Technical Specifications to the Manufacturers

STRATTON & CO. LTD., BIRMINGHAM, 31

In a single application, Araldite epoxy resins combine such diverse functions as bonding, impregnating, insulating and providing surface finishes of remarkable protective value.

This rotating magnet generator, made by Ericsson Telephones Limited for telecommunication equipment, has a greater output than other generators of the same drive torque. It incorporates heavy-gauge iron sheet laminations bolted between diecast alloy end cheeks, and the coil is separately wound on to a moulded bobbin which, when assembled, forms an integral part of the lamination structure. Dimensional accuracy between the end cheeks must be combined with a relatively large dimensional tolerance on the thickness of the laminations, and Araldite Surface Coating Resins have proved indispensable for impregnating the coil, locking the laminations, and imparting an excellent surface finish to equipment which also conforms to tropical specifications.

Combined operations

Araldite epoxy resins are used

- ★ **for bonding metals, porcelain, glass, etc.**
- ★ **for casting high grade solid electrical insulation**
- ★ **for impregnating, potting or sealing electrical windings and components**
- ★ **for producing glass fibre laminates**
- ★ **for making patterns, models, jigs and tools**
- ★ **as fillers for sheet metal work**
- ★ **as protective coatings for metal, wood and ceramic surfaces**

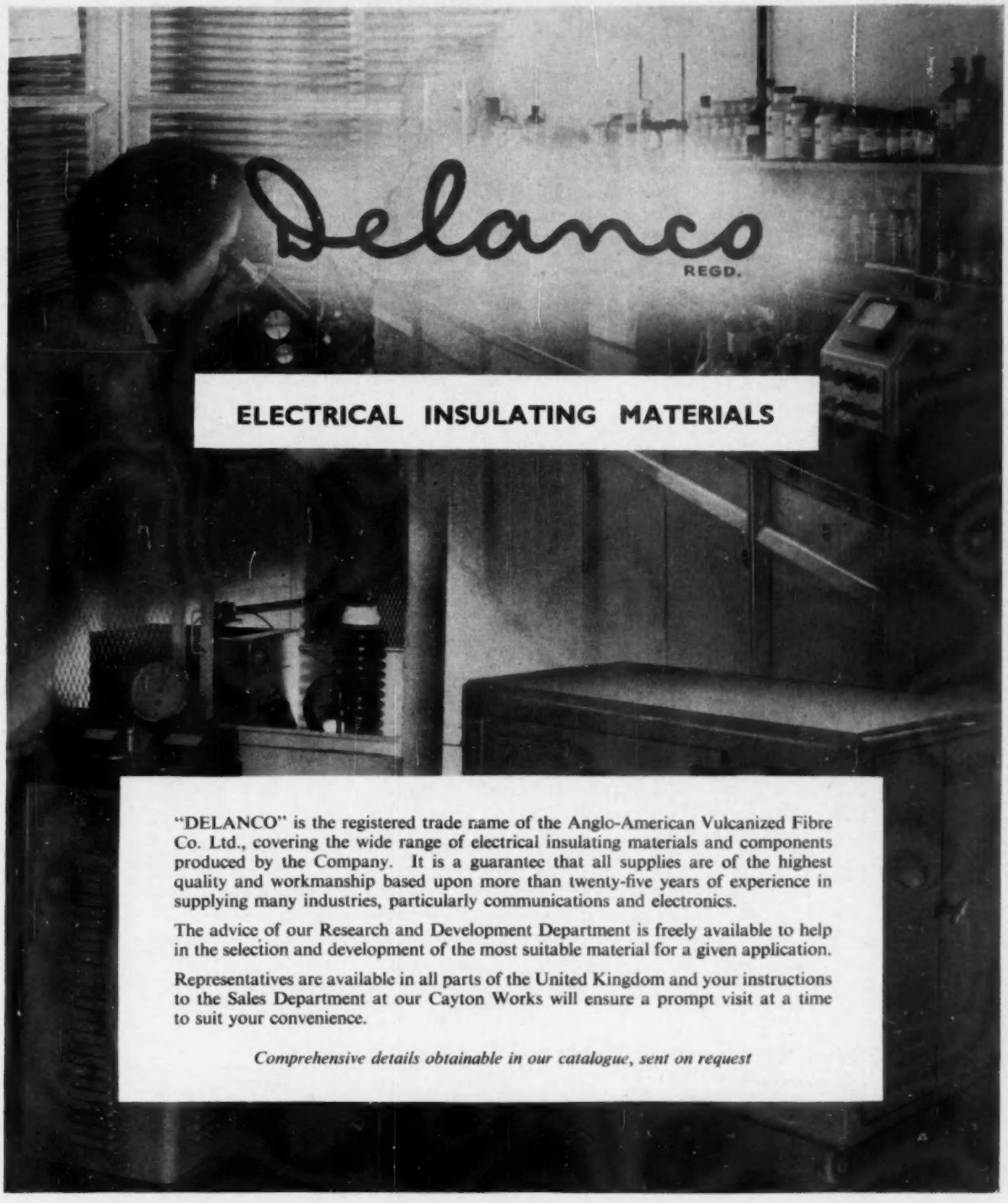
Araldite *epoxy resins*

Araldite is a registered trade name

Aero Research Limited

A Ciba Company. Duxford, Cambridge. Telephone: Sawston 2121

AP 321



"DELANCO" is the registered trade name of the Anglo-American Vulcanized Fibre Co. Ltd., covering the wide range of electrical insulating materials and components produced by the Company. It is a guarantee that all supplies are of the highest quality and workmanship based upon more than twenty-five years of experience in supplying many industries, particularly communications and electronics.

The advice of our Research and Development Department is freely available to help in the selection and development of the most suitable material for a given application.

Representatives are available in all parts of the United Kingdom and your instructions to the Sales Department at our Cayton Works will ensure a prompt visit at a time to suit your convenience.

Comprehensive details obtainable in our catalogue, sent on request

Anglo-American Vulcanized Fibre Co. Ltd

CAYTON WORKS BATH STREET LONDON E.C.1. CLE 3271 Grams: 'PROMPSERV' AVE. LONDON
DELANCO WORKS · LEONARD STREET · LONDON, E.C.2.

VULCANIZED FIBRE · LAMINATED BAKELITE
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Delanco Electrical Insulation

LEATHEROID · MICA · COMPOSITE INSULATION
EBONITE · PRESSED, TURNED and MACHINED COMPONENTS

'dag' colloidal graphite as a conducting coating

REGISTERED TRADE MARK

'Aquadag' colloidal graphite in water is the original wall coating and electrode material for evacuated equipment such as cathode ray tubes, Geiger counters, and radiation meters. There are 'dag' dispersions for the treatment of T.V. cabinets, valve envelopes, anodes and grids; for use as conductor paints in printed circuits; for the prevention of static build-up on ceramic insulators and plastic-insulated high voltage cables; and even, to quote a recent unusual example, as a conducting coating for postage stamps. 'dag' dispersions are also extensively used for the dry-film lubrication of small electrical mechanisms.

This picture shows the application of 'dag' colloidal graphite to the inside of a Cathode Ray Tube bulb

Manufacturers interested in conducting coatings should write for Bulletin 98, a comprehensive outline of electronic and electrical applications for 'dag' dispersions

ACHESON COLLOIDS LIMITED

Subsidiary of Acheson Industries (Europe) Ltd.

PRINCE ROCK • PLYMOUTH • DEVON

Telephone: PLYMOUTH 66351 · *Telegrams:* "OILDAG" PLYMOUTH

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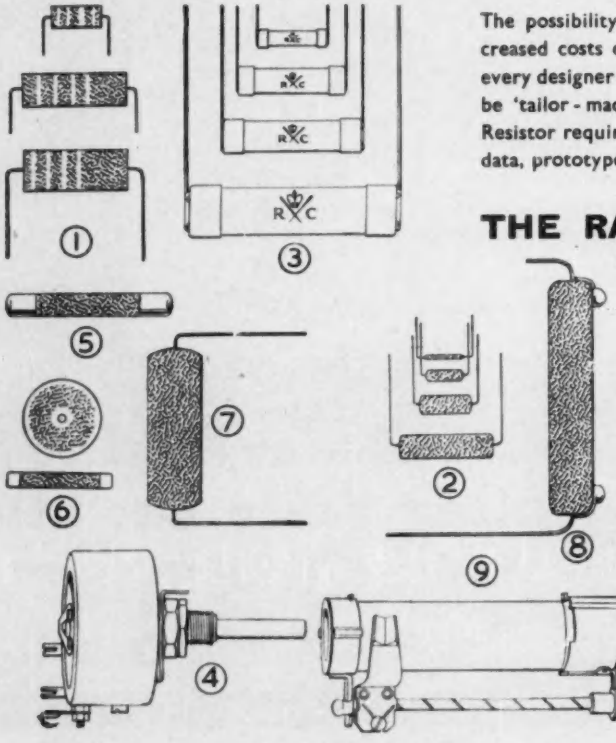
A service for Designers



The possibility of a component change—due to shortage of supplies, increased costs or failure to meet specific conditions—is a problem facing every designer of electronic equipment. However, one basic component can be 'tailor-made' from the start, for LAB will supply the precise type of Resistor required, ex stock *and* at the right price. Write for full technical data, prototype samples and price schedules to:—

THE RADIO RESISTOR CO. LTD.,

50 ABBEY GARDENS, LONDON, N.W.8.

Telephone: Maida Vale 0888

CARBON	WATTS	OHMIC RANGE	TOLERANCES ±
1. Solid	½ 1 & 2	10—10M	5% & 10%
2. Cracked	1/30—20	1—500M	5% & 10%
3. *High Stability	1/10—3	1—50M	0.5% 1% 2% 5%
4. Variable	½	5K—2M	—
5. V. High Resistance	½—3	50M—1013	5% & 10%
6. V.H.F. (Rods & Discs)	1/10—1	10—1K	1% & 2%
WIREWOUND			
4. Rheostats	4—500	10—80K	—
9. Sliders	3—15	10—16K	—
8. Vitreous	3—500	1—150K	1% 2% 5%
7. Cemented	1—15	1—25K	5% & 10%

* The ubiquitous blue (1%) grey (2%) "HISTABS"

Do you KNOW

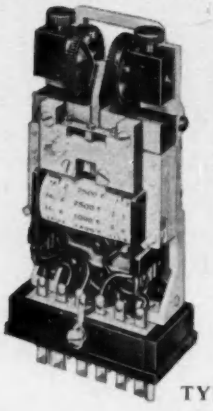
THAT the sub-miniature 1/30th watt unit (2) is probably the smallest production Resistor made.

THAT Almost non-inductive Resistors in cracked carbon are available up to 20 watts rating.

25 YEARS LAB

JUBILEE YEAR OF RESISTOR SPECIALISATION

It doesn't matter whether you call it . . .



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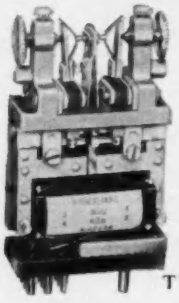

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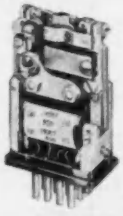

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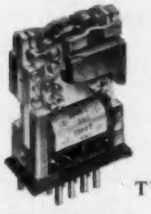
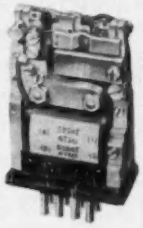


TYPE 51



TYPE 6

5 Basic types are available each with several variations for special purposes.

the **CARPENTER** Polarized Relay

or the Carpenter **POLARIZED** Relay

or the Carpenter Polarized **RELAY**

it is the polarized relay, with the UNIQUE combination of superlative characteristics, that has solved, and is continuing to solve many problems in . . .

High speed switching · Control
Amplification · Impulse repetition

for : Industrial recording
Aircraft control and navigational equipment
Automatic machine control
Analogue computers
Temperature control
Servo mechanisms
Submarine cable repeaters
Burglar alarm and fire detection equipment
Nuclear operational equipment
Biological research
Theatre lighting "dimmer" and colour mixing equipment
Teleprinter working
Automatic pilots
Remote control of Radio links
Theatre stage-curtain control
Long distance telephone dialling
V.F. Telegraphy
etc, etc, etc.

Therefore — if your project, whatever it may be, calls for a POLARIZED relay, with high sensitivity, high speed without contact bounce, freedom from positional error, and high reliability in a wide range of temperature variations, *you cannot do better* than use a CARPENTER POLARIZED RELAY.

Write or 'phone for technical data —

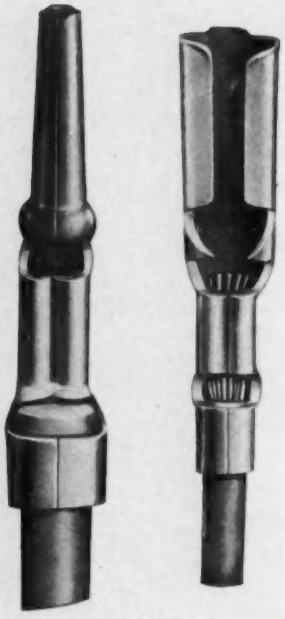
TELEPHONE MANUFACTURING CO. LTD.

DEPT. 407, HOLLINGSWORTH WORKS, DULWICH, LONDON, SE21

TELEPHONE: GIPSY HILL 2211

A-MP* Taper Technique

TRADE MARK



improves the product

cuts the cost

A-MP TAPER PINS, TAPER BLOKS, TAPER TIPS, TAPER TABS and TAPER TAB RECEPTACLES offer great flexibility in circuit design and ensure maximum electrical stability. They cut material cost, labour cost and assembly time. TAPER TECHNIQUE benefits manufacturers of business machines, aircraft, guided missiles and electronic equipment. Write or 'phone us for further information.

A-MP SYSTEMS AID EXPORTS

The **A-MP** solderless method meets wire termination specifications in foreign countries. Use of the **A-MP** method will enable you to compete in world markets. It is particularly significant that **A-MP** systems are standard practice in the U.S.A.

IMPORTANT FEATURES

1. Taper pin diameter standard over a wide range of wire sizes.
2. Self-locking. Resists stress and vibration.
3. High contact pressure giving high conductivity and electrical stability.
4. Automatically crimped connections ensure uniformity.
5. Cuts assembly time. Cuts labour and material costs.

A-MP SOLDERLESS TERMINATIONS—

THE CREATIVE APPROACH TO BETTER WIRING

A-MP* TRADE MARK

AIRCRAFT-MARINE PRODUCTS (GT. BRITAIN) LTD.

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Works: SCOTTISH INDUSTRIAL ESTATES, PORT GLASGOW, SCOTLAND

AP 323-47

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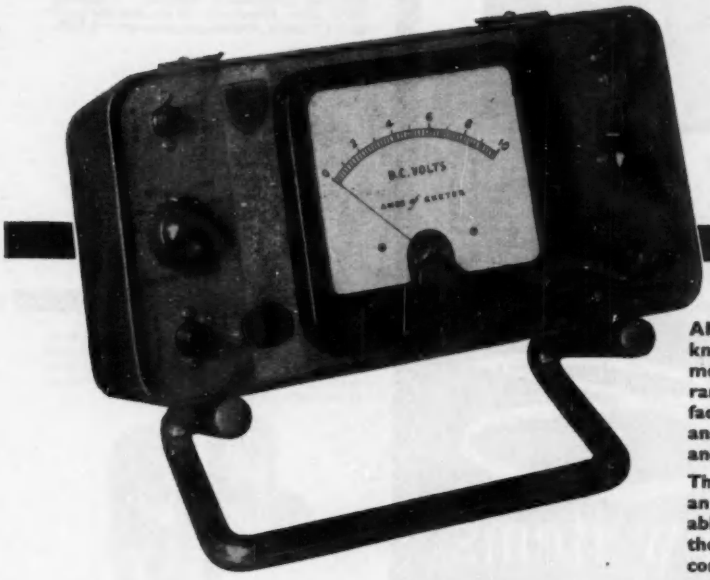


a test of accuracy...

AMOS of Exeter Limited have long been well-known for their design and prototype development work on special transformers. This new range of test instruments, developed and manufactured to rigid specifications, provide accurate answers to vital circuitry testing on the bench and for outside service work.

The Model 140 Transistorised D.C. Voltmeter is an entirely new class of instrument, incomparable with any conventional meter. It combines the high impedance input and minute current consumption characteristics of the valve voltmeter with a useful range of measurement extending from 50 mV to 20,000 volts.

It is the most complete and versatile D.C. voltmeter commercially available, is fully portable, independent of mains supply and more robust in construction than the conventional valve operated electronic meter.

MODEL 140 TRANSISTORISED D.C. VOLTMETER

Six basic voltage ranges are provided, extended by the ÷2 push button to eleven ranges. The first four basic ranges, that is up to and including 1000v, have a sensitivity equivalent to 150,000 Ohms per volt while the additional ranges brought in by the push button have double this sensitivity (300,000 ohms per volt).

VOLTAGE RANGES

			Current draw at F.S.D.
Range 1*	0.5v F.S.D.	Usable from 50mV	3 μA
1	1v "	" " 100mV	6 μA
2*	5v "	" " 0.5v	3 μA
2	10v "	" " 1v	6 μA
3*	50v "	" " 5v	3 μA
3	100v "	" " 10v	6 μA
4*	500v "	" " 50v	3 μA
4	1000v "	" " 100v	6 μA
5*	5000v "	" " 500v	25 μA
5	10000v "	" " 1000v	50 μA
6	20000v "	" " 2000v	100 μA

* USE "÷ 2" BUTTON

INPUT RESISTANCE.

Range 1. 150,000 ohms. Range 3. 15 MEG. ohms. Range 5. 200 MEG. ohms.
2. 1.5 MEG. ohms. 4. 150 MEG. ohms. 6. 200 MEG. ohms.

ACCURACY: Better than 2% of all ranges.

ACCURACY OF INBUILT REFERENCE VOLTAGE: 1%.

STABILITY: Dependent on temperature variations but does not exceed 1% under bench conditions over a period of 2 hours. Correction by means of calibration control.

ZERO DRIFT: Nil.

OVERLOAD: The instrument is automatically protected against accidental overload.

A calibration control provides for the instrument being adjusted to the inbuilt reference voltage against which the meter is calibrated to an accuracy of 1%.

The instrument is presented in a steel case, attractively finished in 'hammerglow' green stoved enamel and provided with carrying handle.

Centre Zero facilities for voltage measurement and for use as a sensitive Galvanometer are provided.

MODEL 156 A.F. OUTPUT METER

A versatile high quality instrument suitable for the measurement of power output in radio and television receivers and high fidelity record reproducers, for the examination of frequency response in audio systems.

POWER RANGES: 10mW., 100mW., 1 watt. and 10 watts., also calibrated in dBs.

FREQUENCY RESPONSE 10 cps — 20KC/s ± .5dB.

The 10 watt input matching trasformer of grain oriented material together with non-inductive precision load resistors, provide matching to inputs of 3 ohms, 5 ohms, 7.5 ohms, 15 ohms and 600 ohms.

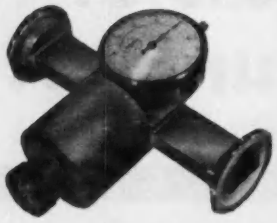
Full technical details and prices available from sole distributors:

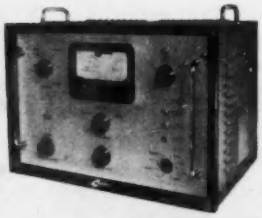
SOUNDRITE LIMITED, 82-83 New Bond Street, London, W.1

LEGation 3618

Agents for: Canada (Mechron Eng. Prod. Ltd.), Denmark (Ditz Schweitzer), Italy (Telecmnia S.R.L.), India (Damodar Manior), New Zealand (W. G. Leatham Ltd.).

Precision Calibrated Attenuator CA. 16/2
Accuracy: 0.1 dB. Frequency Range: 8.0–11.5 kMc/s. Calibrated at 8.5, 9.0, 9.5, 10.0 kMc/s. Attenuating Element: 0–40 dB metallised glass vane type MW146.





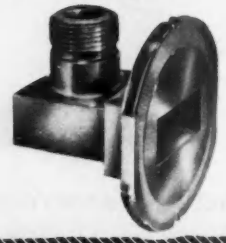
Klystron Power Unit Type PUK.250/350 Mk.II
For low voltage klystrons up to 350 volts at 40 mA. Modulation facilities: 2,000–4,000 c/s, square wave or triangular plus C.W. operation. Fully metered Resonator, Reflector, and Heater Volts and Cathode current. High Stability, ripple not greater than 5mV max.

3 dB Directional Coupler
Binomial Directional Coupler. Coupling value: 3dB. Directivity: 30 dB over the band 8.0–11.5 kMc/s. Attenuation accuracy: ±0.5 dB.

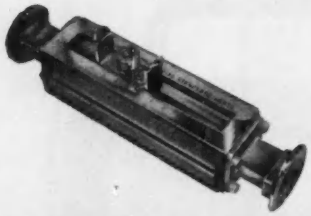
Coaxial Line Cavity. Type CLC.7-12
A coaxial line cavity for plug-in klystrons type CV.2346 (V.X.5028). Output Power: 10 mW Continuous frequency coverage: 7.0–12.0 kMc/s. Built-in Piston Attenuator. Separate calibration graph provided. Supplied complete with klystron and calibration graph.

new items
in an extensive range

Waveguide/Coaxial Transformer. Type X.16/C
Wide band bar and post waveguide to 50 ohm coaxial line transformer. VSWR: 0.8 : 1 over the frequency range 8.6 - 13.0 kMc/s. Coaxial connector - standard type N plug.

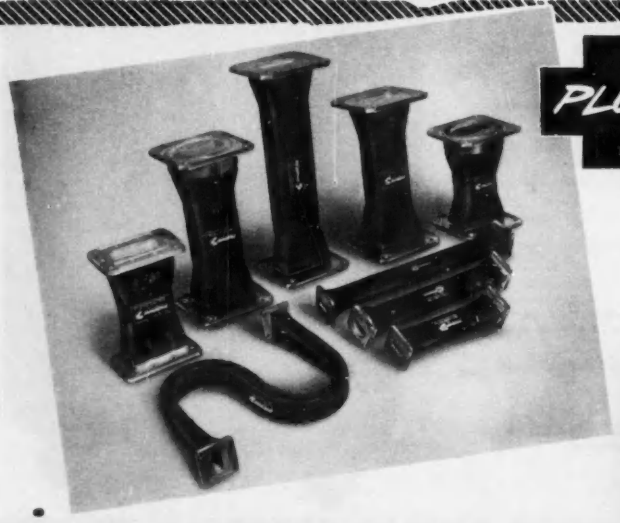


Standing Wavemeter SWM. 16/2
An inexpensive Grade 2 Standing Wave Detector. Accuracy: 3%. Frequency range: 8.0 - 12.0 kMc/s. Suitable for production test and educational purposes.



Magic Tee MGT. 16
Band width: 8% about 9250 mc/s. VSWR: E Arm 0.77: 1. VSWR: H Arm 0.87: 1. VSWR: Through Arm 0.87: 1. Isolation: greater than 40 dB.

Transistor VSWR Indicator/Laboratory Amplifier
Switching to monitor either of two A.C. inputs and bolometer input. Balanced input to compare two anti-phase A.C. inputs. Direct D.C. current readings on 0 to 100 micro-ampere meter. Built-in Bolometer bias-current supply. Selective measurements at 1 Kc/s and 3 Kc/s. Output meter scaled in both 0 to 1 and ∞ to 1 VSWR, and 0 to 0.5 Reflection Coefficient Scale.



PLUS

Flexible Waveguide Assemblies
'FLEXAGUIDE'

S-Type Heat Treated Beryllium Copper Flexible Waveguide Assemblies. Available in W|G.16 (X-Band, 1.0" x 0.5" O|D) and W|G. 10 (S-Band 3.0" x 1.5" O|D). Other popular W|G sizes shortly available. Suitable for repeated flexure and pressurised applications. Meets all M.O.S. electrical specifications. All flange combinations and types available.

Sanders

W. H. SANDERS (ELECTRONICS) LIMITED
Gunnels Wood Road, Stevenage, Herts. *Telephone: Stevenage 981 (6 lines)*
London Office: 49 Conduit Street, London, W.1. *Telephone: Regent 3534*

short-handed?

Only *one* pair of hands is required to operate the Azoflex model 42/63 to produce prints in large quantity—dried, flat and ready for immediate trimming and collating. No darkroom, no elaborate ventilating system and ducting are necessary as there are no unpleasant fumes, and therefore AZOFLEX machines are completely mobile to facilitate reorganisation or expansion. Exposing, developing and print delivery are all synchronised for an even flow of finished work, and output in excess of 100 20″×30″ prints per hour can easily be achieved. AZOFLEX is the *only* daylight reflex copying process and it is the *only* photoprinting process to apply a measured dose of developer, thus ensuring optimum quality.

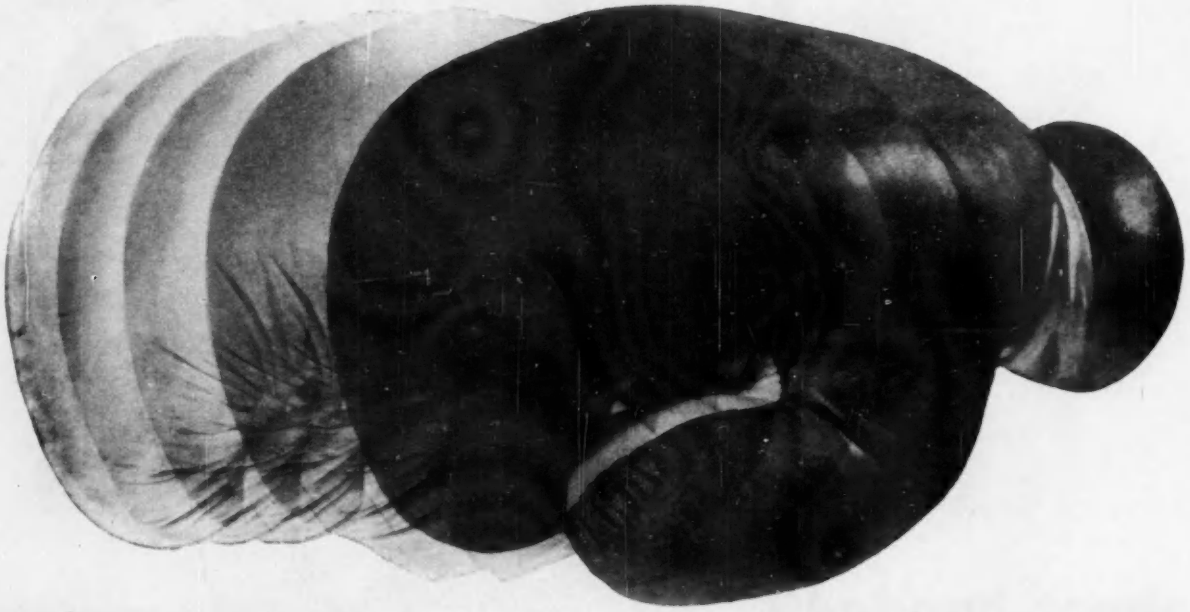
The majority of AZOFLEX photoprinting machines can, subject to certain conditions, be hired as an alternative to outright purchase, where this is preferred.

AZOFLEX MODEL 42/63. Combined synchronised printer and developer. Capacity: cut sheets and rolls up to 42 in. wide. Printing speed: from 6 in. to 15½ ft. per minute. Dimensions: Height 52 in. Width 67½ in. Depth 52 in. with delivery tray extended. Weight: approximately 850 lbs.

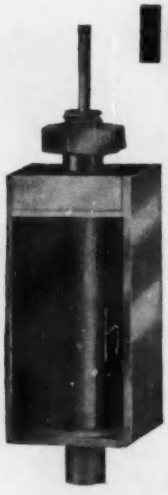
ILFORD *Azoflex*

Enquiries to:
Ilford Limited, Azoflex Dept. AZI40,
104 High Holborn, London, W.C.1
Telephone: HOLborn 3401

MACHINES AND MATERIALS FOR DRAWING OFFICE PHOTOPRINTING



1000 times a minute!



The Varley S.M.O. solenoid is the first of a range of miniature solenoids being developed for the electronic and accounting machine industries.

It can operate about 1000 times a minute through $\frac{1}{8}$ in.

Varley make Solenoids of all shapes and sizes to push or pull anything from ounces to thousands of pounds.

If you need to push, pull, press, prod or punch—*by remote control*—investigate the applications of Varley Solenoids.

They are 100% British in design and manufacture.

For full details of Varley Solenoids send this coupon

Varley

REGD. TRADE MARK

Woolwich 1422

OLIVER PELL CONTROL LTD.
CAMBRIDGE ROW, WOOLWICH, S.E.18

☐ Please send me illustrated booklet "VARLEY SOLENOIDS"
☐ Please arrange for a technical representative to call on me

NAME _____

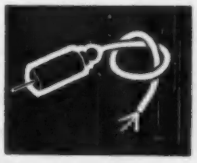
COMPANY _____

ADDRESS _____

_____ E.E.

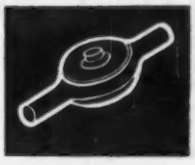
OLIVER PELL CONTROL LIMITED

THE NEW PENDEFORD MULTIMETER



DISPLACEMENT TRANSDUCER

PRESSURE TRANSDUCER



LOAD RING

PRESSURE TRANSDUCER

Typical transducers for use with the New Pendeford Multimeter.

A SELF-CONTAINED PORTABLE SYSTEM OF INSTRUMENTATION

Direct reading of pressure, strain, torque, displacement, load, tension; electrical output for remote indication and recording.

LIGHT IN WEIGHT—SIMPLE TO OPERATE—VERSATILE

SPECIFICATION

Energising supply: 5.0 v.; Max. current 200 mA; Frequency 1 Kc/s; Electrical output $\pm$0.15 mA full scale into 1,500 ohms load; Mains supply 200-250 v. 50 c/s; Dimensions 15″ x 9″ x 6″ deep; Weight (approx.) 20 lb.

Portable, self-contained, simple to operate, these are points of obvious importance today. Checks are so easy—just plug-in the appropriate transducer, set the 6-position selector switch and read off pressure, tension load, strain, or displacement on the directly calibrated scale. The instrument's electrical output enables recording or control to be carried out.

Write for full details of the Multimeter and our new type transducers.

BPA Electronics

for measurement and control

BOULTON PAUL AIRCRAFT LTD., WOLVERHAMPTON.

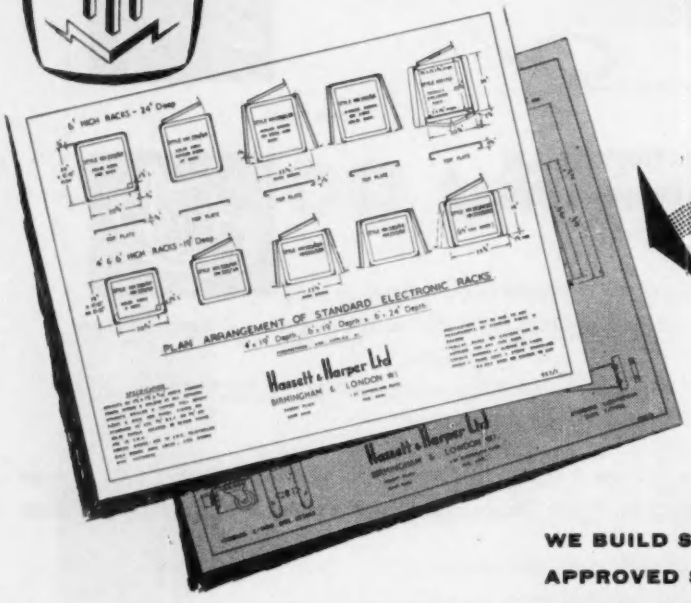
HASSETT & HARPER

STANDARD ELECTRONIC RACKS, CABINETS & CONSOLES

STANDARD ELECTRONIC RACKS

4′ x 19″ 6′ x 19″ 6′ x 24″

AVAILABLE WITH SOLID SIDES AND BACK
OR HINGED SIDES AND BACK
OR HINGED SIDES AND HINGED BACK
OR TOTALLY ENCLOSED



WRITE FOR THESE DATA SHEETS

WE BUILD STANDARD RACKS TO MINISTRY APPROVED SPECIFICATION—THESE CAN BE MODIFIED TO YOUR REQUIREMENTS

Hassett & Harper Ltd

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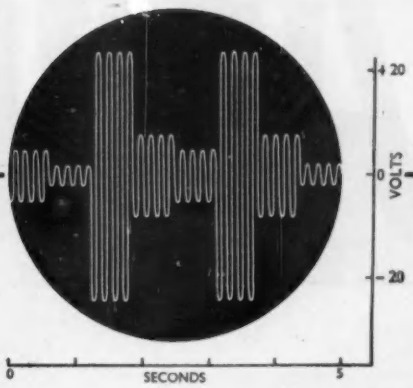
Telephone: CENTRAL 6418

LONDON SHOWROOM: 1 GT. CUMBERLAND PLACE W.1 Tel: PAD. 4691

J 3929

Long persistence for slow processes



New industrial tube 3AFP7

Here is a new and inexpensive cathode ray tube produced specifically for industrial applications where a long persistence screen is required for observing slow or non-recurrent processes. This readily available 2¾-inch tube is invaluable for use with servo mechanisms and a wide variety of control apparatus.

It has a high sensitivity which simplifies deflection amplifier design and the circuitry associated with the tube itself is comparatively simple. Write for full details of the 3AFP7 to the address below.

ABRIDGED DATA

The 3AFP7 is suitable for symmetrical or asymmetrical operation.

Screen

Type P7—Blue flash, yellow afterglow.

Heater

Vh = 6.3V
Ih = 0.55A

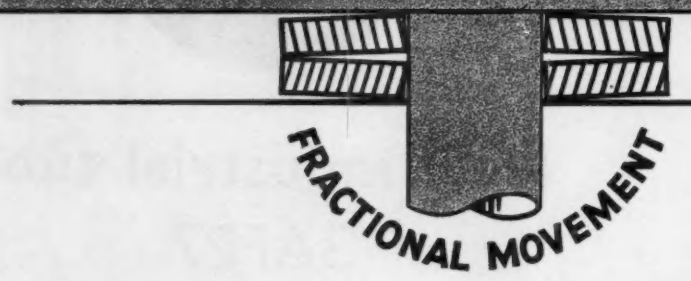
Typical Operation

Va1 + a3	1000V
Va2 (for focus)	210 to 320V
Vg (for cut-off)	−28 to −65V
Sx	20V/cm.
Sy	11.5V/cm.

ETEL Cathode Ray Tubes

ELECTRONIC TUBES LIMITED • Kingsmead Works • High Wycombe • Bucks • Telephone: High Wycombe 2020
ETLS

LARGE LOAD



. . . and the Belleville makes it possible . . . !

The largest capacity spring balance in the world. This instrument was made to weigh giant steel castings and is graduated up to 200 tons with 1 ton sub-divisions. It is approved by the Board of Trade for "Trade" purposes, where the requirement is that the machine must be accurate to within a quarter of its smallest sub-division.
Two Belleville washers, in this instance opposed to each other, supply the spring resistant. Their total movement under full load of 200 tons is never more than $\frac{1}{16}$ of an inch.

SALTER...

...always a spring ahead!

★ When resistance to load or thrust is beyond the capacity of helical springs,

★ When take-up of shock or sustained load must be restricted to very slight movement,

★ When many tons of dead load must be sustained plus intermittent shock or live load . .

It's time to call in* SALTER *technicians

GEO. SALTER & CO. LTD., WEST BROMWICH, ENGLAND . ESTABLISHED 1760

Presenting A *New* FREQUENCY STANDARD

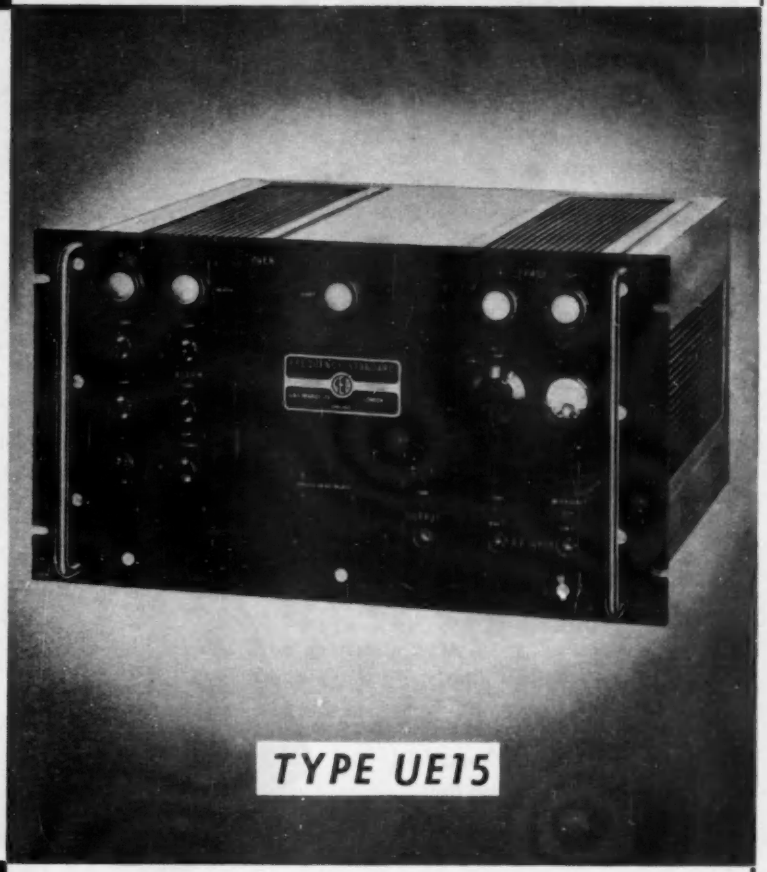
Day-to-day frequency stability better than one part in 10^6, and short-term stability better than one part in 10^7 are features of this new 100 Kc/s. Frequency Standard.

Internal receiver unit continuously monitors the second harmonic from the output of the standard, together with the B.B.C. Droitwich 200 Kc/s. transmission, and indicates visually the phase relationship between the two signals.

Crystal-controlled oscillator employs a GT-cut crystal which is mounted in an oven maintained at 70°C.

Output:
Sine-wave at 100 Kc/s.
Amplitude:
6·3 volts R.M.S. ± 20% into 100 ohms.

Designed for standard 19" rack mounting and finished in black stove enamel.



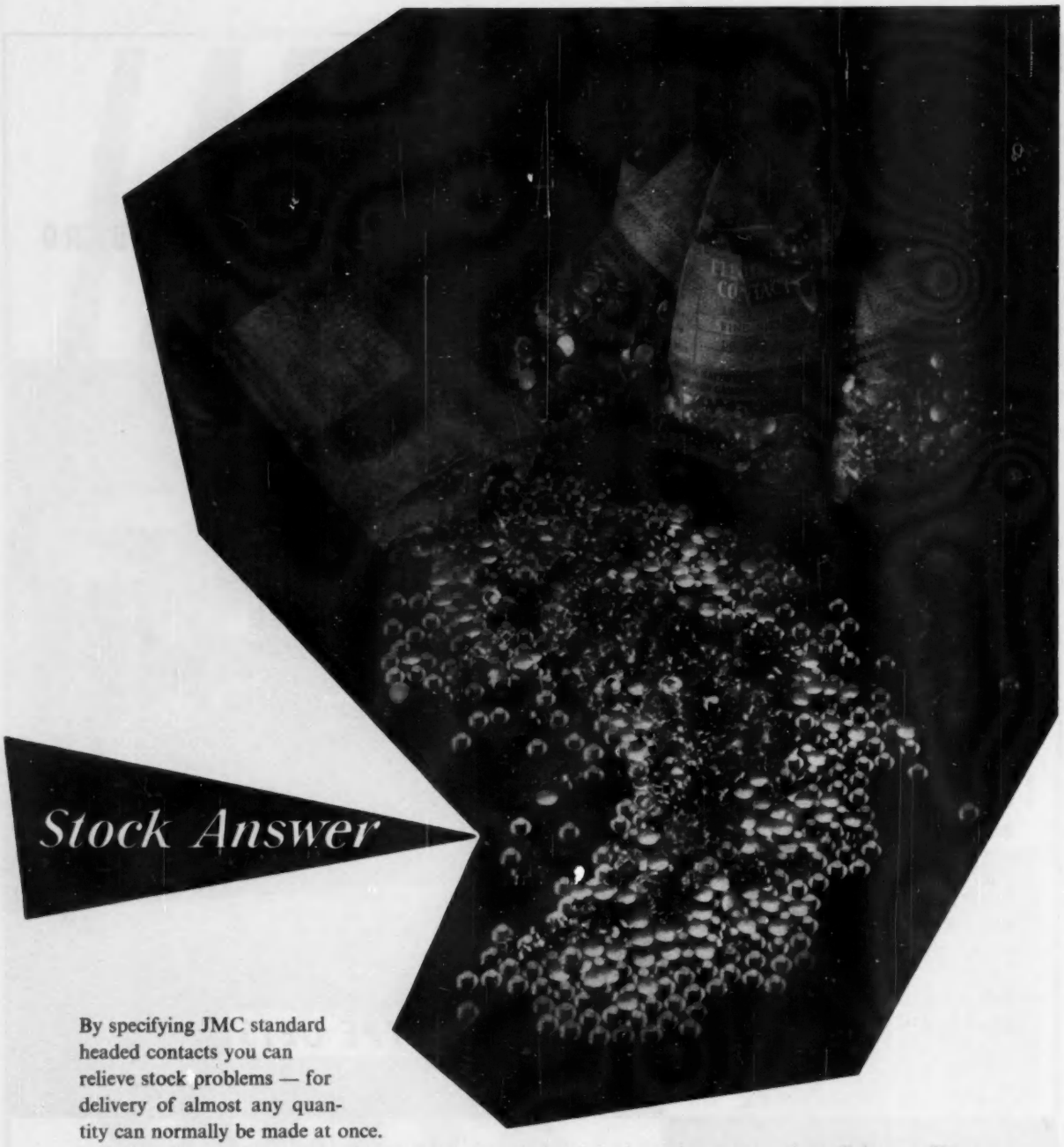
TYPE UE15

GEB

G. & E. BRADLEY LTD.

ELECTRAL HOUSE · NEASDEN LANE · LONDON · NW10

TELEPHONE: GLADSTONE 0012-7 · TELEGRAMS · BRADELEC · LONDON NW10



Stock Answer

By specifying JMC standard headed contacts you can relieve stock problems — for delivery of almost any quantity can normally be made at once.
To this, add the advantages of lower cost, sound design and maximum operating efficiency. The stock answer to many problems of contact selection — and a convincing one — is the adoption of JMC standards.

ONE OF THE SPECIALISED PRODUCTS OF

Johnson JMC Matthey

A series of technical data sheets is free on request.

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73-83 HATTON GARDEN, LONDON, E.C.1. Telephone : Holborn 6989

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SC 2

First in the field

GOLTOP

POWER TRANSISTORS

available NOW in commercial quantities

These have been in regular quantity production for the past two years, and have proved themselves reliable and stable in a *variety* of applications. They are admirably suitable for all forms of DC to DC or DC to AC Converters, High Power portable Amplifiers and Public Address Equipment. "GOLTOP" Power Transistors are the first to be offered for immediate delivery in quantity. Representing the latest developments in semi-conductor technique for power applications, these entirely British-made p-n-p Germanium Junction Transistors will open up entirely new fields to designers of industrial, commercial and military equipment.

Available in 6 TYPES, all for 10-watts power dissipation:
V15/10P. V15/20P. V15/30P. for 15 volts max.
V30/10P. V30/20P. V30/30P. for 30 volts max.

Maximum Collector Power Dissipation (DC or Mean) for all types	$t_{amb}=25°C$	$t_{amb}>25°C$ *Reduction/°C*
(1) Clamped directly on to 50 sq. in. of 16 S.W.G. aluminium	*10W*	*200mW*
(2) Clamped directly on to 9 sq. in. of 16 S.W.G. aluminium	*4W*	*80mW*
(3) As (2) but with 2 mil mica washer between heat sink and transistor	*2W*	*40mW*
(4) Transistor only in free air	*1W*	*20mW*

* **High power rating—up to 10W at audio and supersonic frequencies.**
* **High current ratings up to 3A DC.**
* **Long life.**
* **Excellent resistance to mechanical shock.**
* **Hermetic sealing and rigorous manufacturing control ensure uniformity and stability of a high order.**

British Design, Materials and Craftsmanship

Data sheets gladly forwarded on request

All trade enquiries to: **Newmarket Transistor Co. Ltd.**

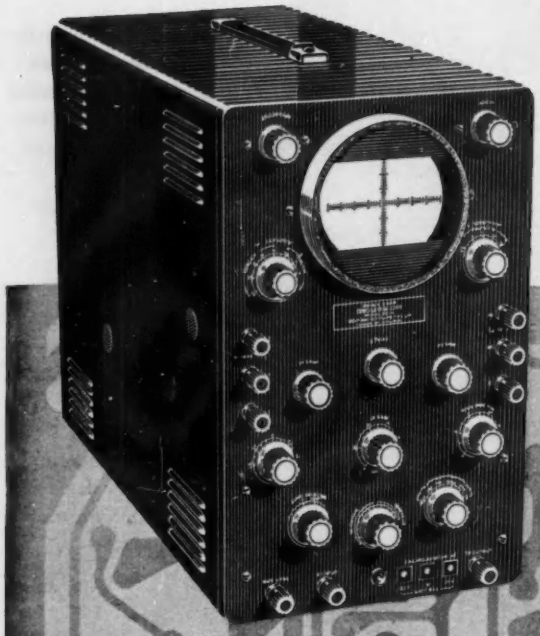
Exning Road, Newmarket. *Telephone: Newmarket 3381/4*

TA 10705

PERFORMANCE ASSURANCE WITH

COSSOR

PRINTED CIRCUITS



Model 1071K ***Double Beam*** *Kit Oscilloscope*
List Price £69.0.0
Hire Purchase Facilities
Trade Terms on Application

AN INSTRUMENT RANGE IN KIT FORM

Q. *Why has Cossor Instruments decided upon this innovation?*

A. To make available a range of first-class measuring instruments **at a considerable saving in cost to the Buyer.**

Q. *Are Kit instruments inferior in performance to their Factory-built equivalents?*

A. Certainly not. If assembled and wired exactly in accordance with the Manual of Instructions.

Q. *A certain skill must, surely, be required to build these instruments?*

A. None beyond the ability to use a small soldering iron.

Q. *How can a performance specification be maintained without setting up with test equipment?*

A. Largely by the use of PRINTED CIRCUITS which allow no interference with the layout of critical parts of the circuit.

Q. *How many Kit instruments are at present available?*

A. Three. Two Oscilloscopes, a Single-Beam and a Double-Beam, and a Valve Voltmeter. Others will follow shortly.

Q. *Could I have more information on these interesting instruments?*

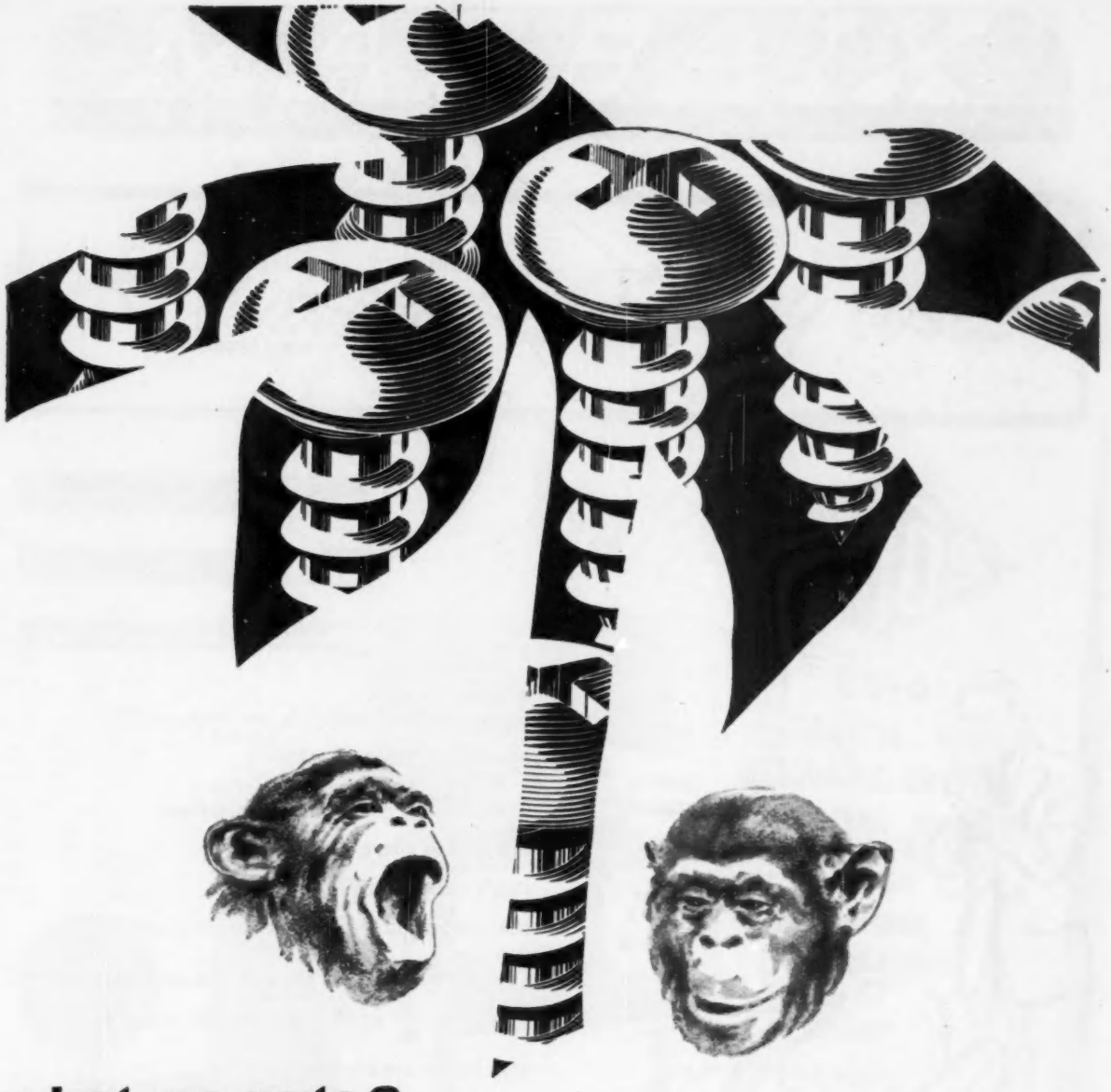
A. With the greatest of pleasure. Just write to:

COSSOR INSTRUMENTS LIMITED

The Instrument Company of the Cossor Group

COSSOR HOUSE · HIGHBURY GROVE · LONDON, N.5

Telephone: CANonbury 1234 (33 lines) Telegrams: Cossor, Norphone, London Cables: Cossor, London



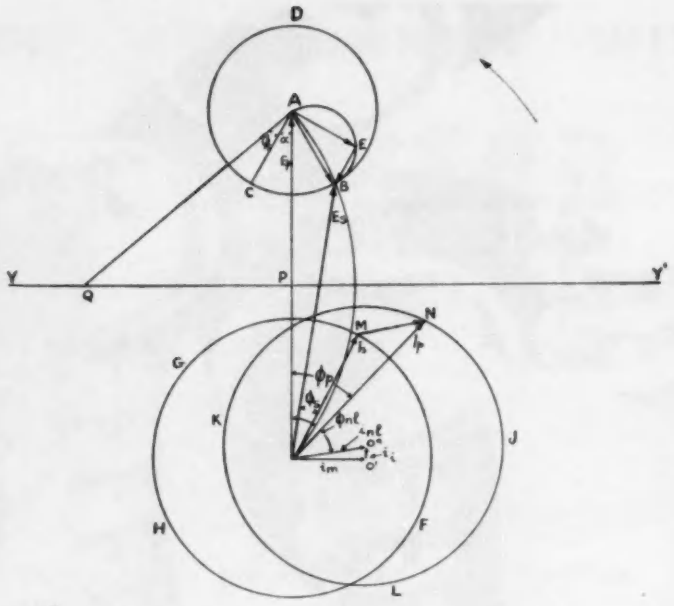
what, no nuts? . . .

Nuts to use nuts? Well, not exactly, but the fact that the Tapping Screw obviates the use of nuts is just one of its distinct advantages over the conventional Machine Screw. There's the saving in time to consider too. And cost. And there's no doubt whatever that the tapping screw makes for a better job all round. With its self-locating point the tapping screw forms its own thread thereby eliminating a separate and expensive tapping operation. Obviously it makes for easier assembly, is stronger, cheaper and faster. Safer too when the Phillips recessed head is specified, designed for power driving without damage to worker or job. You'll be well advised to change over to Tapping Screws. Nothing nuts about that !

Linread

LINREAD LTD. COX ST. BIRMINGHAM 3

SLOTTED AND PHILLIPS RECESSED HEAD MACHINE SCREWS AND TAPPING SCREWS • HIGH TENSILE HEXAGON HEAD BOLTS AND SETSCREWS AIRCRAFT BOLTS, SCREWS AND RIVETS • SEMS • RIVNUTS • CUSTOM DESIGNED COLD FORGED FASTENERS • ALEX SCREWPLUGS.



—Supposing they don't list one which will exactly do the job?

—Well they've got 600 to choose from; but even if there's nothing there ready on the shelf, their design crew will soon produce one.

—. . . At any rate look through the catalogue first: that gives the gardneristics of the whole lot . . .

—which may save weeks . . .

—exactly . . .

—we're getting on quite gardneristically aren't we my dear boy?

Gardners **TRANSFORMERS & CHOKES**

are fully described in a loose leaf Catalogue available on request.

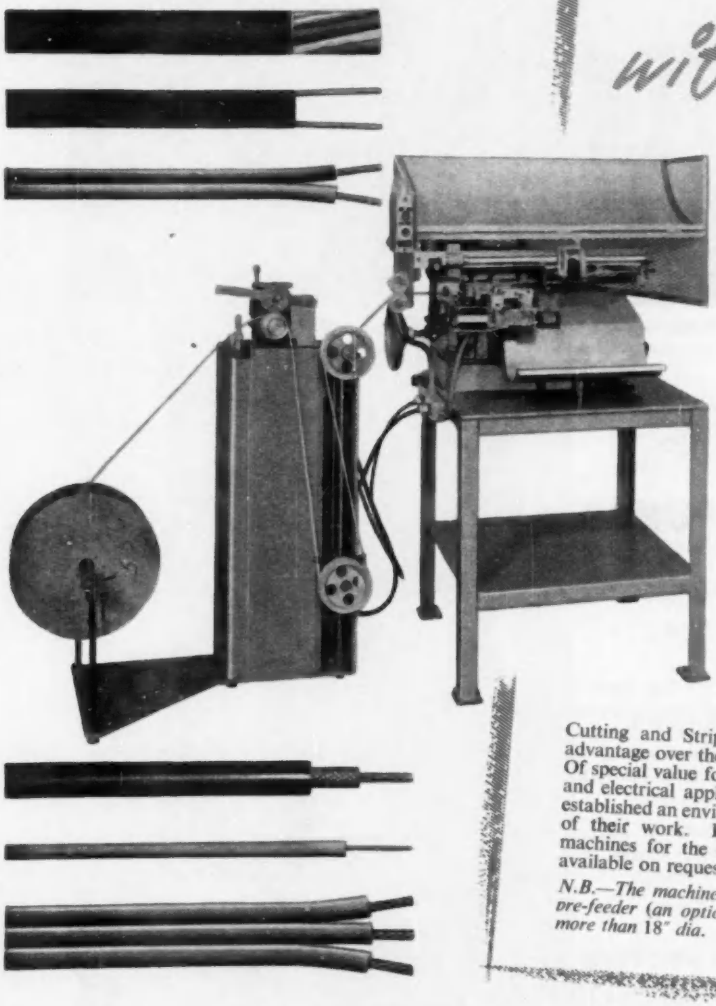
GARDNERS RADIO LTD., SOMERFORD, CHRISTCHURCH, HANTS. ***Tel.*** **CHRISTCHURCH 1024**

MARBAIX

FOR UNUSUAL MACHINES

* cut wire stripping costs

with ARTOS



CS-6

AUTOMATIC WIRE MEASURING, CUTTING & STRIPPING MACHINE

(Now built in Europe)

Four operations in one

- UNREEL
- MEASURE
- CUT
- STRIP

— Automatically

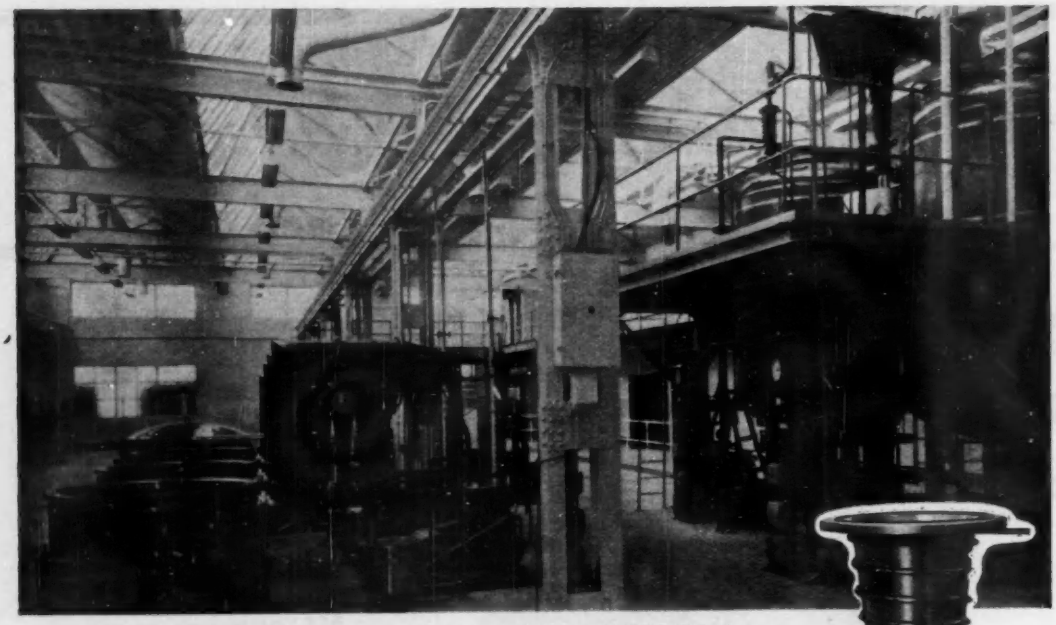
If you want to step up production and reduce wire cutting and stripping costs, an ARTOS Automatic Wire Measuring, Cutting and Stripping Machine will show a remarkable advantage over the best manual or semi-automatic methods. Of special value for suppliers to the motor, radio, television and electrical appliance industries, ARTOS machines have established an enviable reputation for the speed and accuracy of their work. Full details of this and other ARTOS machines for the electrical and automotive industries are available on request to Dept EE/2.

N.B.—The machine illustrated is shown with variable speed pre-feeder (an optional extra) for feeding extra heavy reels more than 18" dia.

GASTON E. MARBAIX LTD

DEVONSHIRE HOUSE, VICARAGE CRESCENT,
BATTERSEA, LONDON, S.W.11
PHONE: BATTERSEA 8888

Laboratory High Vacuum Standards in Industrial Processing



Photograph by courtesy of Messrs. Johnson Phillips showing a battery of "SPEEDIVAC" Booster pumps forming part of an installation which we supplied for drying power capacitor elements.

"SPEEDIVAC"

BOOSTER VAPOUR PUMPS

A COMPLETE RANGE OF CAPACITIES
FOR LABORATORY AND FACTORY

The high quality power capacitors produced at the new Johnson Phillips modern factory demand a new standard of vacuum drying. The consequent need for great pumping speeds and complete freedom from contamination were adequately provided for by "SPEEDIVAC" BOOSTER PUMPS and OIL-SEALED AIR-BALLAST ROTARY PUMPS.

Similar pumping systems are installed throughout the country for CHEMICAL, METALLURGICAL, IMPREGNATION and ATOMIC ENERGY applications.

For better vacuum service . . .

EDWARDS HIGH VACUUM LTD

MANOR ROYAL · CRAWLEY · SUSSEX CRAWLEY 1500 (10 LINES) EDCOHIVAC CRAWLEY

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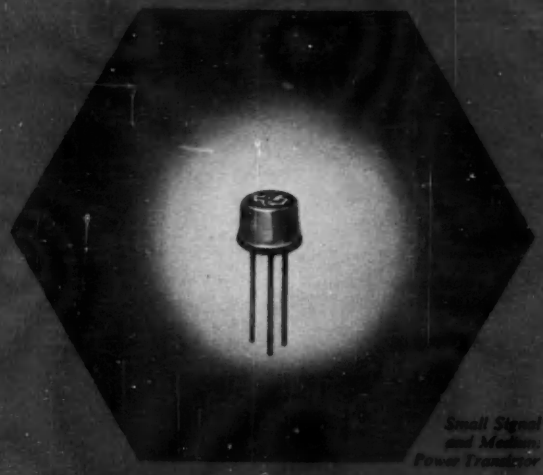
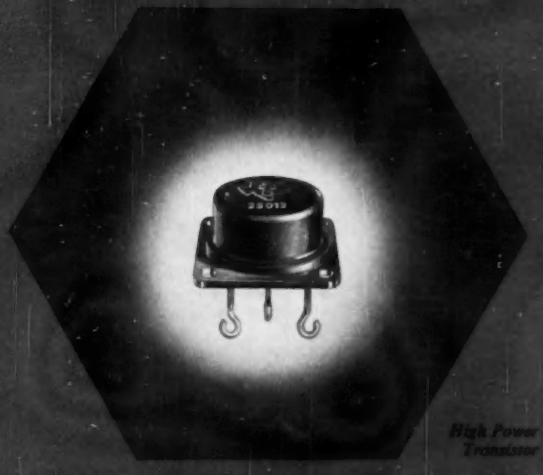
HERE and NOW TEXAS

HAVE THE RANGE...



Small Signal and Medium Power Transistor



High Power Transistor

750 mA Rectifier

All illustrations are actual size

Transistors

The first complete range of silicon transistors available in this country is now in production at Bedford.

Texas *H.F. tetrodes* and *small signal* transistors are used in high gain, low level circuits operating at frequencies up to 30 Mc/s.

The new and versatile 4-watt 100-volt *medium power* transistor is particularly suitable for driving many types of servo motors.

Your *high power* requirements will be supplied by our 37½-watt transistor with a typical beta cut-off frequency of 300 Kc/s.

Rectifiers

Texas *metal-case* and *glass-seal* rectifiers feature a P.I.V. of 600 volts together with a mean rectified current of 750 mA and 400 mA respectively.

Silicon *rectifier stacks* are available for use in heavy duty power supplies.

Silicon gives you

Reliability
ensured by high permissible junction temperature.

Stable operation
over wide temperature range.

Versatility in application
provided by high collector voltage ratings.

Rugged design
to meet military requirements.

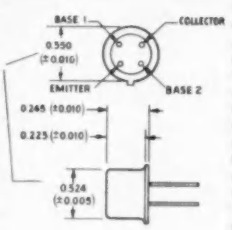
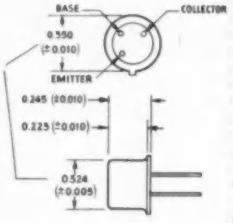
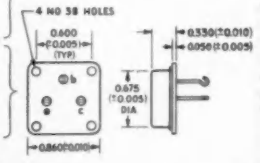
SEE TABLE OVERLEAF

TEXAS INSTRUMENTS LIMITED
DALLAS ROAD, BEDFORD, TEL: BEDFORD 68051, CABLES: TEXINLIM, BEDFORD

N-P-N. SILICON TRANSISTORS

All maximum ratings refer to a case temperature of 25°C, except where otherwise stated.

All units are capable of storage or operation at temperatures within the range −50°C to +150°C.

	Type No.	MAXIMUM RATINGS				CHARACTERISTICS					Dimensions in inches
		Collector Dissipation		I_C Mean	Collector Breakdown Voltage	Small Signal Current Transfer Ratio-h_{fe}		Alpha Cut-off Frequency Mc/s	I_{CO} at V_C = 30V µA	Saturation Collector Resistance ohms	
		at 25°C Watts	at 100°C Watts	mA	Volts	Min.	Max.	Min.	Max.	Max.	
H. F. TETRODES	3S001	0.125	0.05	10	30	Power Gain = 18 db Min. at 12.5 Mc/s.					
	3S002	0.125	0.05	10	30	Power Gain = 16 db Min. at 30 Mc/s.					
	3S003	0.125	0.05	10	30	Power Gain = 20 db Min. at 4 Mc/s.					
SMALL SIGNAL	2S001	0.15	0.1	25	45	9	20	4	2	200	
	2S002	0.15	0.1	25	45	18	40	4	2	200	
	2S003	0.15	0.1	25	45	18	90	10	2	200	
	2S004	0.15	0.1	25	45	36	90	4	2	200	
	2S015	0.15	0.1	25	45	76	250	4	2	200	
	2S014	0.125	0.05	20	40	20*	55*	10	1	300	
	2S005	0.125	0.05	20	40	45*	150*	20	1	300	
MEDIUM POWER	2S017	4.0	2.25	200	60	12	36	0.2‡	10	40	
	2S018	4.0	2.25	200	100	12	36	0.2‡	10	40	
HIGH POWER	2S012	37.5	15.0	2 Amp	60	10**	30**	0.3‡		6	
	2S013	37.5	15.0	2 Amp	60	10**	30**	0.3‡		10	

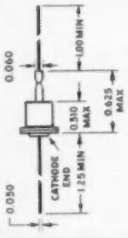
* D.C. Current Transfer Ratio. ** Large Signal Value. ‡ Typical Beta Cut-off Frequency.

SILICON COMPUTER DIODES

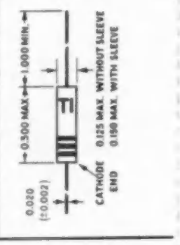
Type No.	P.I.V. −65° C to +150° C Volts	Max. Recovery Time µ secs.	MAXIMUM RATINGS 25° C Average Rectified Current mA	25° C Max. Rev. Current at P.I.V. µA	100° C Average Rectified Current mA	100° C Max. Rev. Current at P.I.V. µA	Dimensions
1S301	50	0·3	100	5	30	25	As for Glass-Seal Rectifiers (below)
1S302	100	0·3	100	5	30	50	
1S303	200	0·3	100	10	30	100	

SILICON RECTIFIERS

METAL-CASE

Type No.	P.I.V. −65° C to +150° C Volts	Average Rectified Current	Max. Rev. Current at P.I.V. µA	Max. Fwd. Voltage Drop at I_o = 500mA Volts	
1S001	200	750 mA at 50° C 500 mA at 100° C	10	1.0	
1S002	300				
1S003	400				
1S004	500				
1S005	600				

GLASS-SEAL

Type No.	P.I.V. −65° C to +150° C Volts	Average Rectified Current	Max. Rev. Current at P.I.V. µA	Max. Fwd. Voltage Drop at I_o = 400mA Volts	
1S111	200	400 mA at 25° C 250 mA at 100° C	0.2	1.0	
1S112	300				
1S113	400				
1S114	500				
1S115	600				

SILICON RECTIFIER STACKS

Half wave, full wave and bridge configurations provide a maximum D.C. output current of 18 Amps. and operate from single phase and polyphase supplies up to 3,360 volts R.M.S.

TEXAS INSTRUMENTS LIMITED

DALLAS ROAD, BEDFORD, TEL: BEDFORD 68051, CABLES: TEXINLIM, BEDFORD

Texas Instruments reserve the right to make changes at any time in order to improve design.

FEBRUARY 1958

ADVANCE COMPONENTS LTD., ROEBUCK ROAD, HAINAULT, ILFORD, ESSEX TELEPHONE HAINAULT 4444

10 to 300 Mc/s DIRECTLY CALIBRATED

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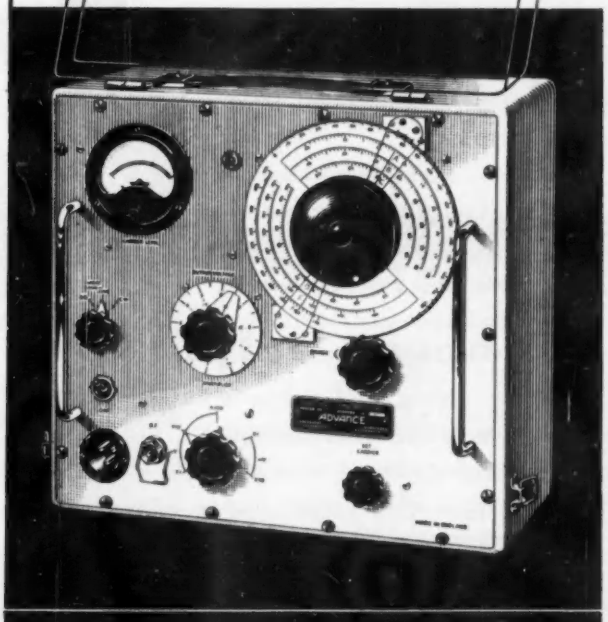
NETT PRICE IN U.K.

£97

Full technical details available in leaflet M43



MODEL DI/D

The ADVANCE V.H.F. SIGNAL GENERATOR TYPE DIP/2

Directly calibrated in six ranges

2 Mc/s to 190 Mc/s

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This is a special version for the alignment of narrow band communication receivers which incorporates:

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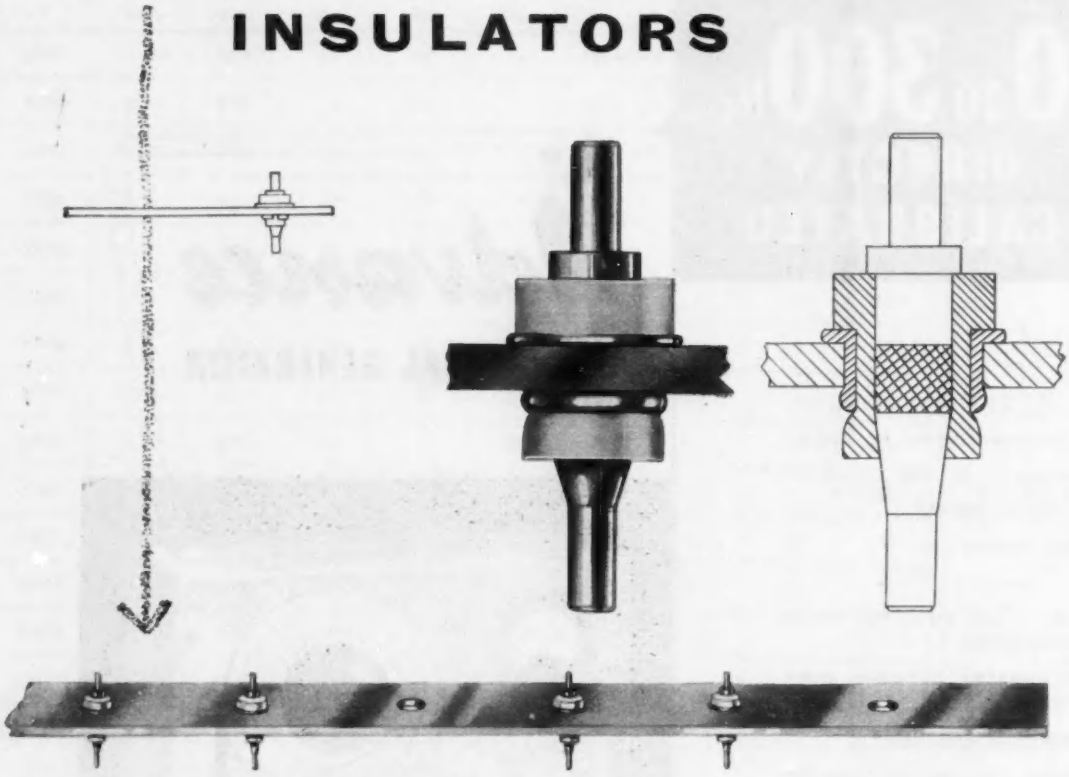

speed output and save money

The new lead-through insulator will be welcomed by all electronic engineers, particularly those faced with rising production costs. Like all good inventions it is incredibly simple, and because it has been developed by Polar engineers you can be sure it is highly efficient. (Pat. pending).

It requires a chassis hole of ⅜" diameter, and consists of a tapered brass terminal pin (suitably finished for quick soldering) with a P.T.F.E. sleeve which is re-inforced with a brass collar providing additional resistance to side-thrust. Assembly is a matter of seconds by inserting it into the hole, and pushing home the terminal pin with a suitable hand tool to ensure a tight fit and rigid assembly. Samples for testing purposes on your own production lines are available free of cost on request.

TECHNICAL DATA

Terminal Pin	Tin-plated Brass	Insulator	P.T.F.E.
Collar	Tin-plated Brass	Working Voltage	1500v peak
Max. Current	3 amps.	Insulation	Better than 10 k megohms
Capacity	Terminal to chassis, 1.6 pF		

Available for two thicknesses of chassis :

Type LT1-11	for 20 gauge (.036")	Type LT1-21	for 16 gauge (.064")

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WR25

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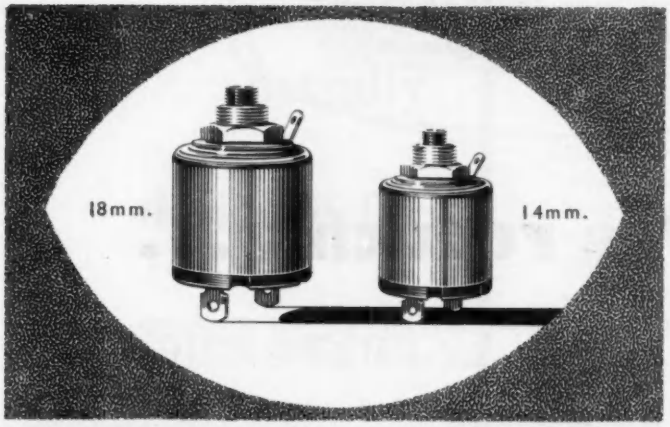

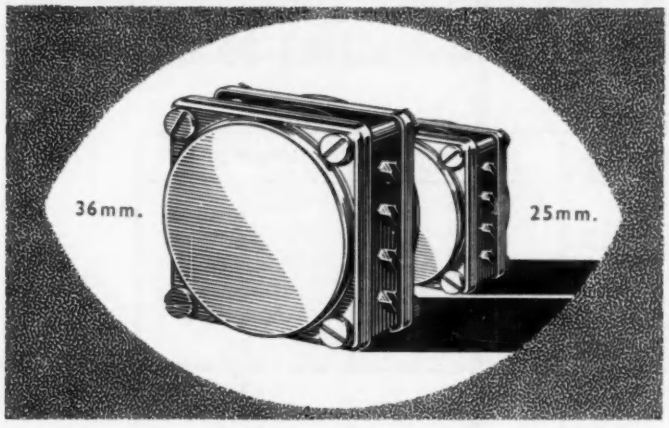

* Pot core design facilitating rapid assembly
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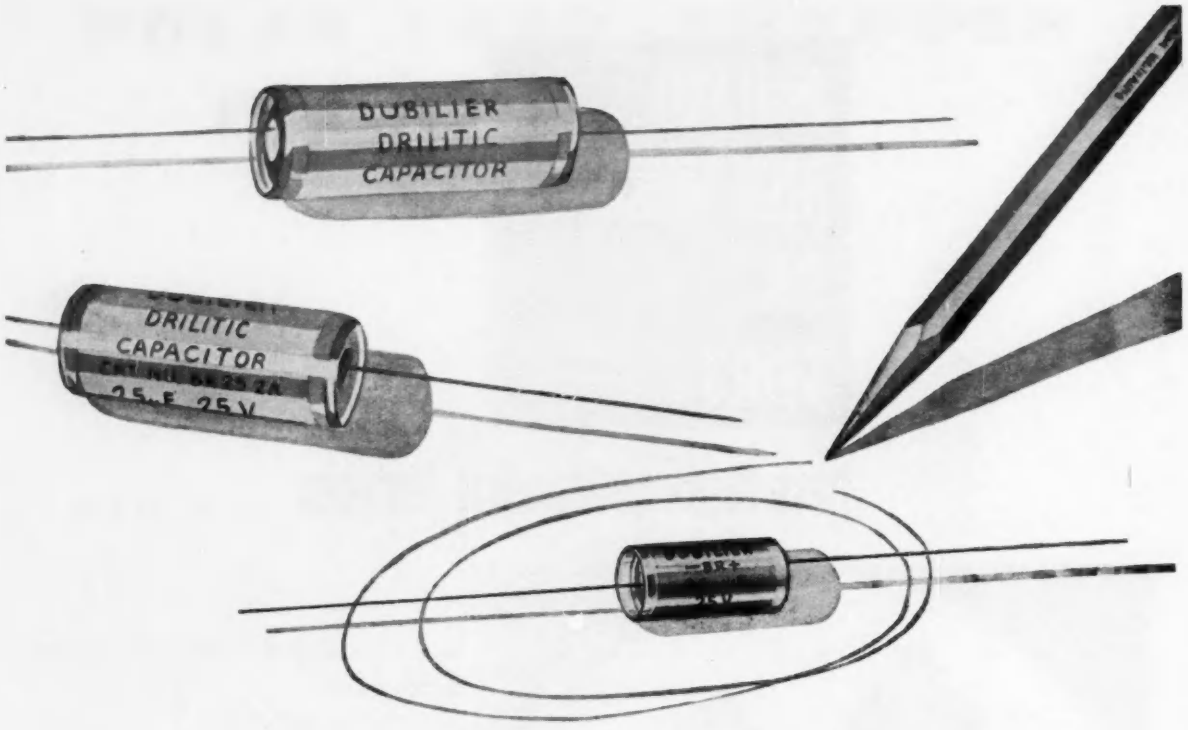

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the size of our electrolytic capacitors. The new type BR miniature electrolytic capacitor retains all the characteristics of this well-known range with the added advantage of reduced size.

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25	12	$\frac{7}{16}$	$\frac{3}{4}$
50	12	$\frac{7}{16}$	$1\frac{1}{16}$
10	25	$\frac{7}{16}$	$\frac{3}{4}$
25	25	$\frac{7}{16}$	$\frac{3}{4}$
5	50	$\frac{7}{16}$	$\frac{3}{4}$
10	50	$\frac{7}{16}$	$\frac{3}{4}$
4	100	$\frac{7}{16}$	$\frac{3}{4}$
8	100	$\frac{7}{16}$	$1\frac{1}{16}$
2	150	$\frac{7}{16}$	$\frac{3}{4}$
4	150	$\frac{7}{16}$	$\frac{3}{4}$

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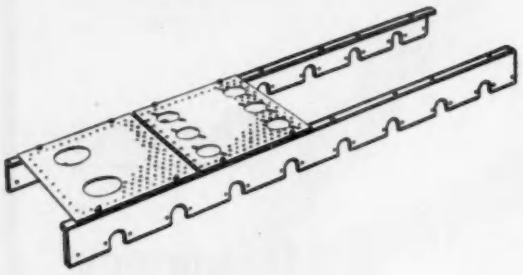
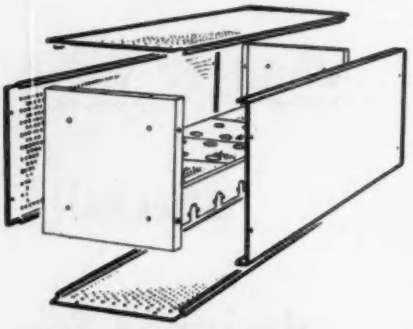


HOW LONG
does it take ?

HOW MUCH
does it cost ?

to produce an experimental chassis

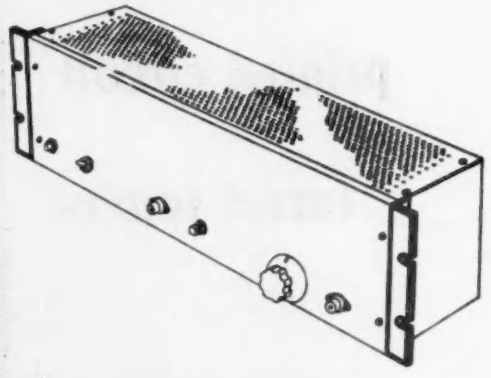


If you don't already know, please spare a while to find out.

Then, when you are horrified by the answers, spare a little more time

to

investigate



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CL88

22 contacts

"Wedgelock" rivets

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Recommended for top performance in electronic and communications equipment, the Plessey G.A.2 switch provides dependable long-life action —even under arduous service conditions.

Of advanced design and construction, which permits 22 contacts per wafer and achieves unique compactness and lightness, this switch incorporates the highly successful "Wedgelock" riveted contact clips. Positive location in all switching positions is assured, the contacts remaining permanently rigid, withstanding even excessive tangential pressure.

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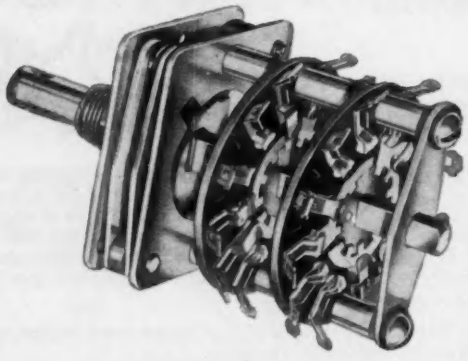

SPECIFICATION

Initial Contact Resistance (Maximum)	5 milliohms
Insulation Resistance (all contacts to spindle)	500 MΩ @ 500V. D.C.
Contact Current	5 amps RMS continuous
Contact Rating	150 mA @ 250V. RMS non-reactive load 250 mA @ 110V. RMS

The Plessey G.A.2 switch

* Type Approval Certificate No. 1116 H.2. Grade 1. RCS 15

- **Up to 22 fully insulated contacts per wafer (double-wiping, self-cleaning type)**
- **30° Index (12 positive switching positions)**
- **Providing for unusual contact arrangements**
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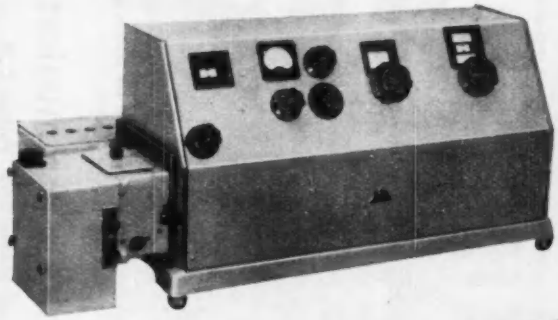
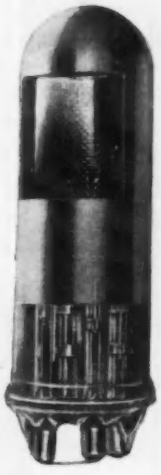


PHOTO CELLS IN ACTION



TYPE QVA 39

The Unicam Photoelectric Quartz Spectrophotometer† widely used for visible and ultraviolet investigations, employs two 'Cintel' Photocells one of which is illustrated.

This all quartz envelope cell is a typical example from the wide range of types in current production; in fact there is a 'Cintel' cell available for almost every known application.

†*Photograph by courtesy of Unicam Instruments Ltd.*

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10, 20 and 30 kilovolt regulated supply

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output	50kV at ½mA
input	200/250 volts
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regulation	against full load: better than 1% against mains variation: +5%,—5%. Better than 1%
dimensions	W: 25½" H: 23" D: 11½"

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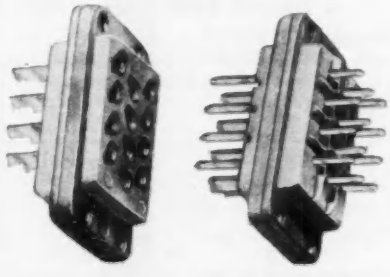
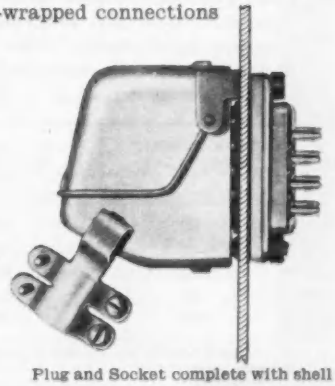


12 way Plug and Socket in Mikacin Moulding



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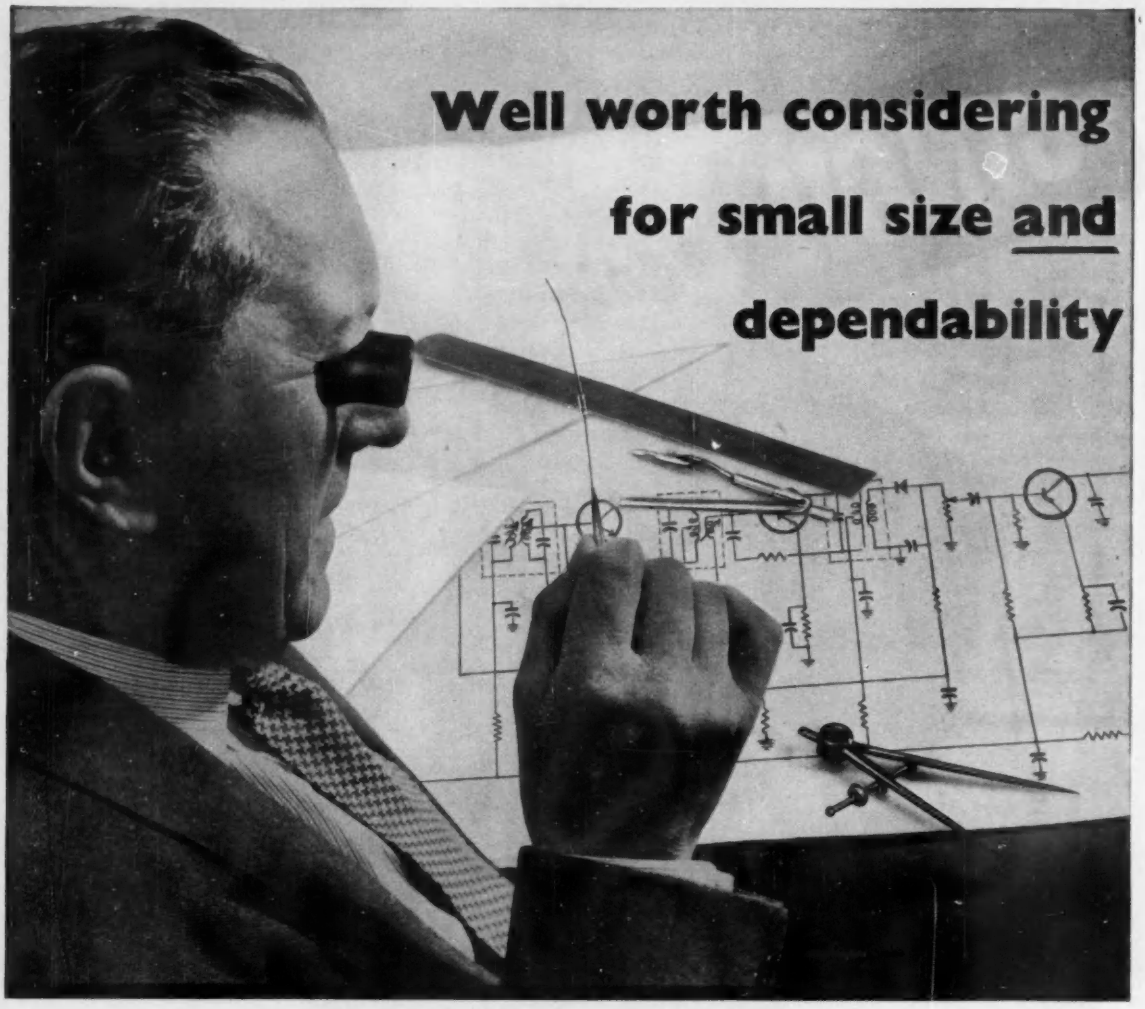

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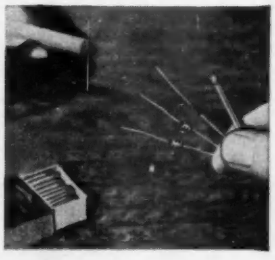
CG41–H	65	30	250	50
CG42–H	100	30	500	1,000
CG44–H	80	30	333	500
CG50–H	100	30	500	200

*Type CV 448 has been granted 'type approval'. †Corresponds to 1·2 mA inverse current.



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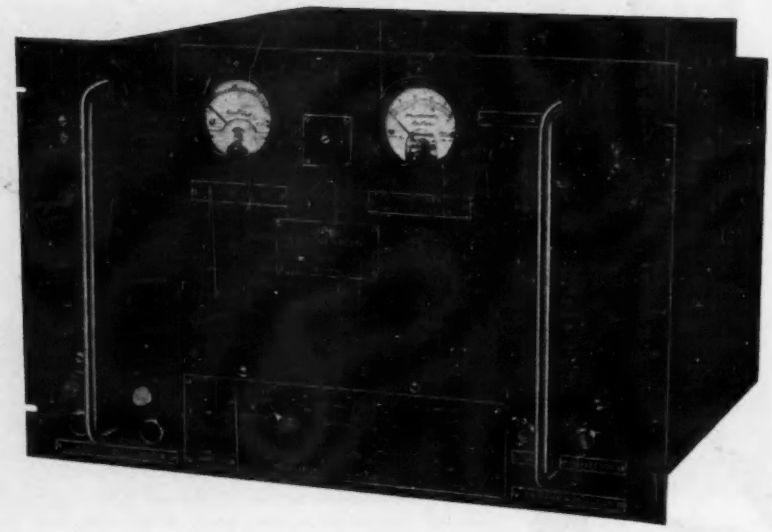
THE Power Unit Type 698B which is available for **immediate delivery,** is designed to provide H.T and L.T. supplies for high voltage Klystron valves. All the H.T. supplies are stabilised, the output being less than 0.5 per cent of the input voltage changes. Internal Oscillators provide square wave and saw tooth wave modulation and switching from an external source, to be applied to the grid or reflector voltages. A switch position is also provided for operation under C. W. conditions.



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Cathode Volts	Cathode Current	Grid Max	Volts Min	Reflector Max	Volts Min
—2.4kV (Max)	18 mA	—220V	0	—500V	0
—1 kV (Min)	10 mA	—100V	0	—280V	0

Stabilisation: Output change of less than ± 200mV for input change of 210—250V

Ripple Voltage: Not greater than 20mV R.M.S.

Regulation: Output impedance less than 500 ohms at 10 mA.

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Rating: 4.0V—D.C. at 1.4A
Ripple: Less than 150mA R.M.S.

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Vol. 30
No. 360

FEBRUARY 1958

Electronic Engineering

Managing Editor: H. G. FOSTER, *M.Sc., M.I.E.E.*

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ELECTRONIC ENGINEERING

VOL. 30 No. 360

FEBRUARY 1958

Commentary

THE Post Office has recently introduced a number of changes into the public telephone service of Great Britain. To the subscriber. the immediate effect of these alterations is that a number of calls which previously cost up to one shilling now cost only threepence, while the area in which numbers may be dialled direct has been considerably increased.

These changes are, however, only part of a much larger plan which is described in the recent White Paper, "Full Automation of the Telephone System". In this it is stated that the Post Office is taking two big steps towards full automation of the telephone system.

The first step, which has already been taken, is the introduction of simplified charges, and in this section of the Paper it is pointed out that since the first automatic exchange came into service in 1912 progress towards full automation has been held back by a system of charges designed for manual operation. This changeover, while calling for very little additional equipment, will cut telephone costs by about £2M a year.

The second step, for which the first step is designed to pave the way, concerns full automation. The first exchange to be converted will be Bristol and by the end of this year new equipment will allow subscribers in that city to dial about half the subscribers in the country. It is anticipated that, by the end of 1960, 40 other towns will be similarly equipped and that by 1970 three-quarters of all trunk calls will be dialled by subscribers.

To complete this second step a considerable amount of new and relatively complex equipment will be required; the "brain" of the new system being a machine devised by Post Office research engineers and known as GRACE (Group Routing and Charging Equipment). This equipment will interpret the numbers dialled by subscribers and route calls in the required direction. It will operate switches at intermediate telephone exchanges until the required exchange is reached and will then dial the number on that exchange. Automatic charging will take place and the charges for all calls will be recorded on the subscribers meters. To enable this to be accomplished the present three-minute minimum charge will be abolished and all calls will be charged in units of the local call charge (3d.). This will buy time according to distance. For example, when a Bristol subscriber dials an Edinburgh number his meter will register once when the call starts and again every 13 seconds until the call is finished; but on a call to Gloucester, which is considerably nearer, the meter will register only at 45 second intervals. It will, of course, be necessary to retain some operators to provide such specialized services as personal calls and reverse charge calls etc., but, by substituting machines for people for most of the routine work, great savings will be made and in ten years' time it is anticipated that savings of the order of £15M a year will be effected.

It is pointed out in the White Paper that the greatest problems of automation are not in the technical field, but that the human problems are much greater. Men and women are displaced. less staff is required and career prospects are jeopardized; all of which can cause much anxiety and hardship. However, thé Post Office intends that full telephone automation shall be undertaken with the goodwill of the staff and that full regard will be paid to the interests of those who have given long service and to such added responsibilities as may be carried by staff in the future. There will be many such problems to be solved and these will be tackled together by the Post Office and the Trade Unions. The Trade Unions have declared their willingness to co-operate in the introduction of automation and. indeed, their members are already serving on working parties set up to consider its introduction and problems.

While few people will disagree with the statement that the greatest problems of automation are in the field of human relations, and while the Post Office are to be heartily congratulated on the way in which they have approached this problem, it must, nevertheless, be appreciated that the technological advances which have made these developments possible are of no small order. In fact, the research and engineering teams responsible are worthy of the highest praise for, in addition to the fairly complex nature of some of the equipment which has had to be devised, the reliability requirements for equipment used in so vital a public service are extremely stringent and, also, due to the very large capital expenditure involved, the equipment installed must have a projected life of many years.

If all goes according to plan, this will be a considerable technical and economic achievement and should prove a fine example of what can be achieved in the field of automation when the technologists and humanists are united in their efforts.

Automatic Control of Ground Instrumentation During the Launching and Flight of Experimental Guided Missiles

By R. J. Garvey*, B.Sc.(Eng.)

The article describes a programme switch associated with the launching and flight of experimental guided missiles. This unit switches control and recording equipment on and off automatically to a pre-arranged programme set up for the particular missile. The switching is effected by two uni-selectors which control output relays according to time settings on a selector board. There are 30 output channels and each one can be preset to switch remote equipments on and off at any time during a 14 minute automatic cycle.

IN launching and flight testing an experimental guided missile, it is necessary to effect a sequence of switching operations on control and recording instruments in the various ground stations on the range and also to the missile before it is launched. The complexity of the missile and ground instrumentation, as shown by Figs. 1 and 2, and the necessity for accurate timing in some cases, requires that the switching be made automatically. The 'programme switch', illustrated by Fig. 3, has been designed to do this. It switches equipment to a pre-arranged sequence or programme set up for each test flight; a typical programme being given by Table 1.

It would be possible to control the switching manually but this introduces a risk of one or more of the personnel involved failing to operate the equipment at the correct time, or at all, particularly during the last few seconds before launching. This could result in the missile being launched in a faulty condition with inadequate ground instrumentation in service. A costly missile would then be wasted since it is normally expended on the single test flight. Manual switching for the more complex missiles has in fact proved impractical and automatic control is regularly used.

The programme switch operates automatically for a maximum period of 10min preceding the launching time followed by a 4min run to cover the flight of the missile. Each output channel can be quickly and independently pre-set to switch remote equipments on and off at any time during the 14min cycle. Thirty output channels are available with three outlets on each, permitting the control of a maximum 90 remote equipments. An indicator fitted to the programme switch counts off each second with respect to zero time, i.e. the time at which the round is launched. The officer controlling the shoot observes this and announces the time at suitable intervals over the range communication system. This officer is in close communication with all range stations and if necessary can halt the automatic operation of the programme switch.

The flight tests and whole range instrumentation depend on the correct functioning of the programme switch; due care has therefore been taken in designing the equipment to ensure that it operates reliably. All parts of the equipment are readily accessible for servicing and a packaged construction permits any vital faults to be quickly eliminated by plugging in replacement units.

The description here refers to equipment designed to meet a specific requirement. The basic circuit is, however, adaptable and could be used for the control of industrial processes. Another adaption would be suitable for use in

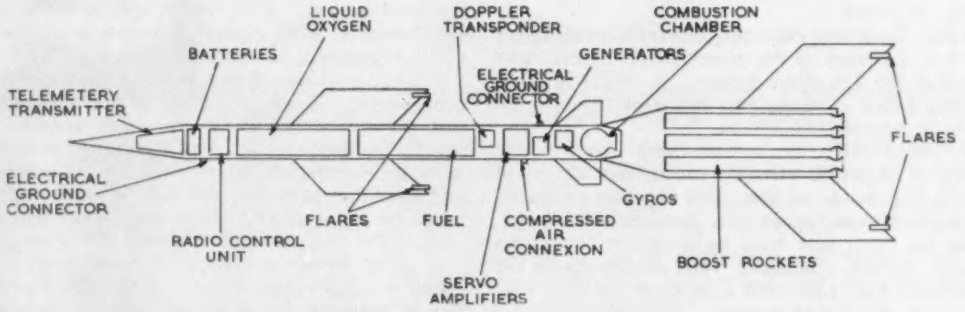


Fig. 1. Typical guided missile equipped with control unit and telemetry transmitter for test flight

TABLE I
Typical Firing Programme

TIME	OPERATION
−5m	Electrical ground supplies switched to missile.
−4m 45sec	Compressed air supplied to gyros and servos in missile.
−4m 30sec	Telemetry aerial spinner switched on.
—	Operation of telemetry and control systems checked.
−2m	Missile switched on to internal supplies.
—	Operation on internal supplies checked.
−30sec	Fuel tanks primed.
−20sec	Electrical connexions to missile ejected.
−15sec	Compressed air line to missile ejected.
−4sec	Tail flares ignited.
−2sec	Cine-theodolites switched on.
−1sec	Launcher camera switched on.
−1sec	Radar recorder switched on.
−1sec	Telemetry recorders switched on.
−1sec	Doppler recorder switched on.
−1sec	Priming signal switched to central timer.
zero	Boost motor fired.
+1sec	Launcher camera switched off.
+30sec	Target cameras switched on.
+40sec	All circuits switched off.
+4m	Programme switch reset.

* *The Royal Aircraft Establishment.*

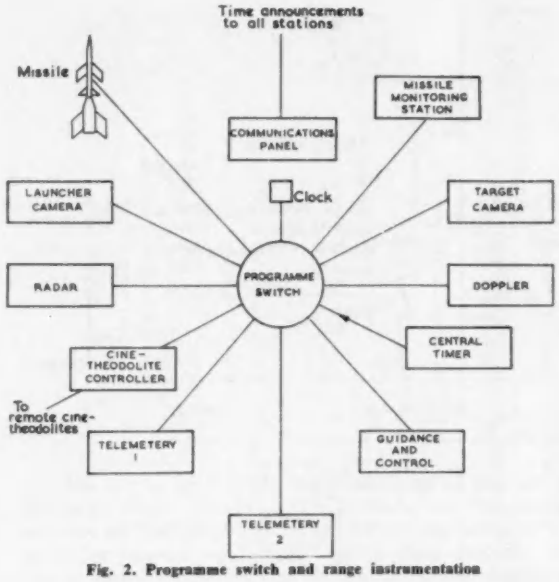


Fig. 2. Programme switch and range instrumentation

the field to fire operational missiles. Possible developments of the circuit design in this respect are discussed very briefly below.

General Description

A 1p/s operating signal is supplied to the programme switch from the range 'central timer'. This timer[1] consists of a 10kc/s oscillator and frequency dividing circuits which supply timing and reference signals to the various measuring and recording instruments used on the range; it functions as a separate equipment. The programme switch could be operated independently but it is better to synchronize all automatic switching operations with range time.

Referring to Fig. 4: the 1p/s operating signal is fed via a pulse amplifier to Post Office type uniselectors which switch voltages to a special selector board. Output relays control remote equipment in the missile and ground stations according to the time settings on each channel of the selector board. The uniselectors commence stepping in synchronism with the 1p/s signal when the operator presses the start button, run through a 14min cycle and automatically reset for another run. The operator can, however, interrupt the run for any length of time by operating the stop and start switches or, if necessary, reset the uniselectors before the cycle is complete.

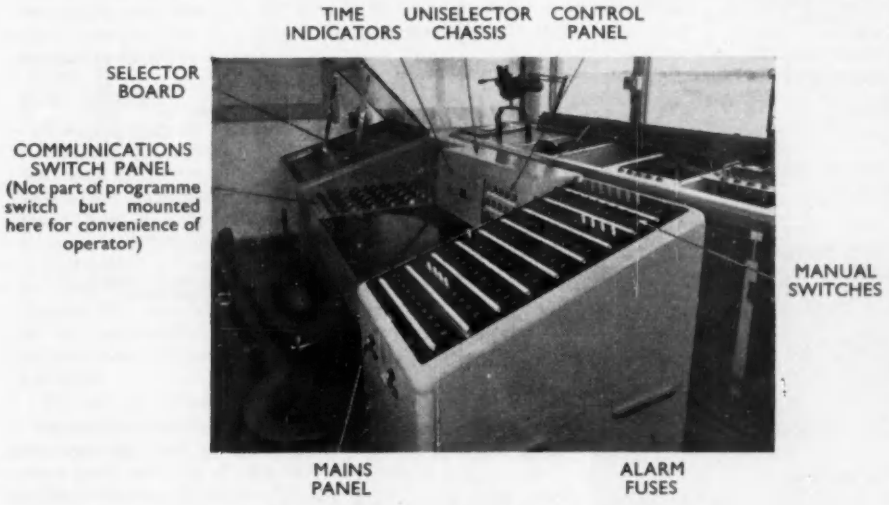


Fig. 3. Programme switch installed in central control room

Fig. 5 illustrates the method of operation in more detail. The selector board shown consists simply of a lattice of horizontal and vertical conductor bars arranged so that connexions can be made between them by inserting studs at the intersections. Uniselector *A* steps in synchronism with the 1p/s operating signal and switches a positive supply successively to 60 of the horizontal bars. Uniselector *B*, which is stepped once per minute by *A*, switches an earth in succession to the remaining 14 horizontal bars.

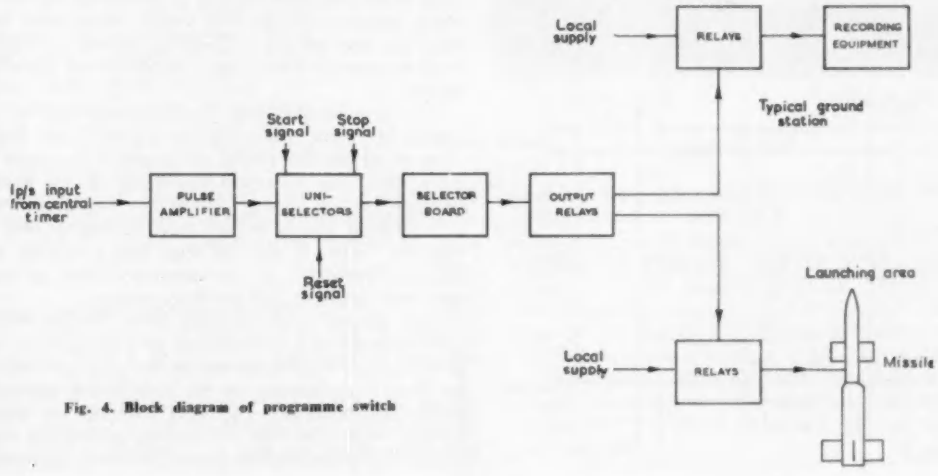


Fig. 4. Block diagram of programme switch

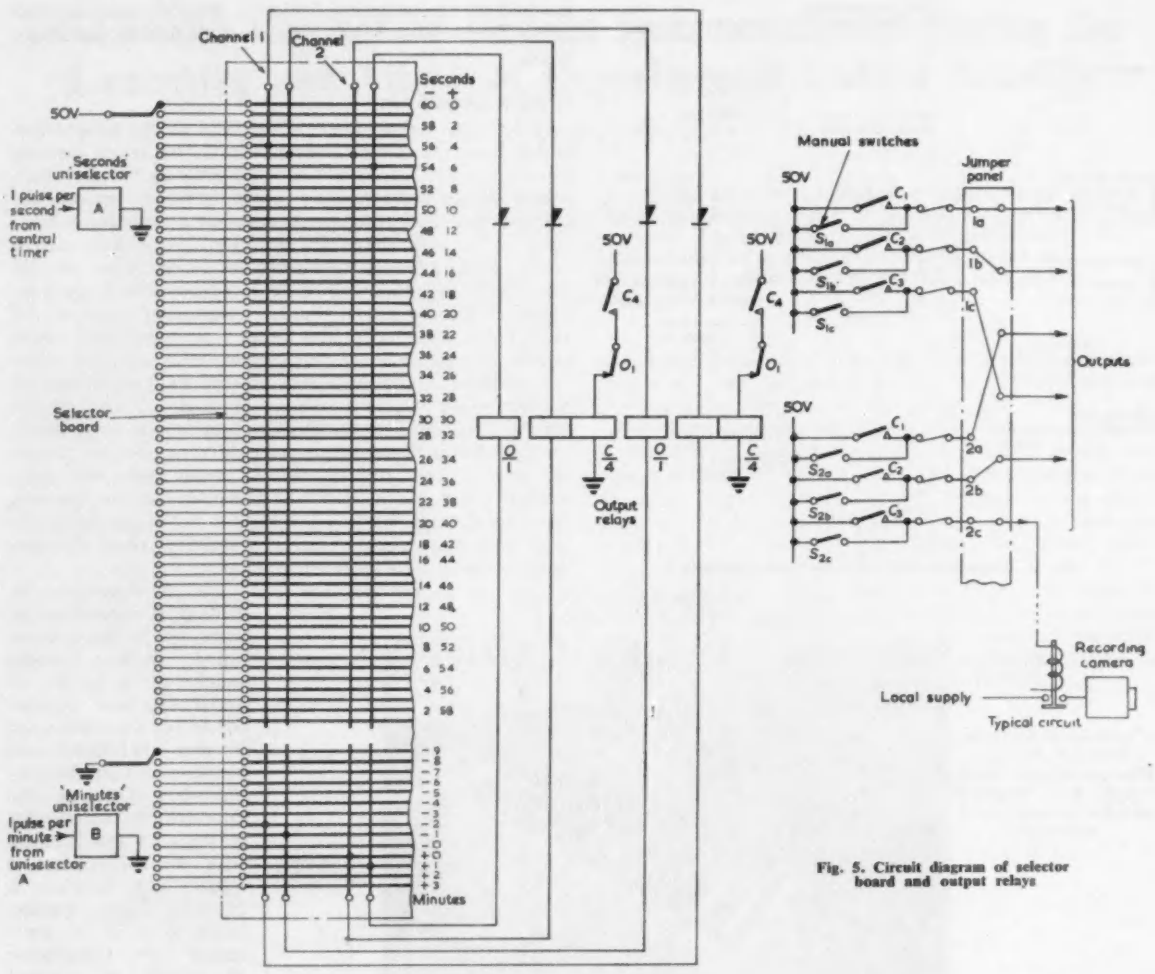
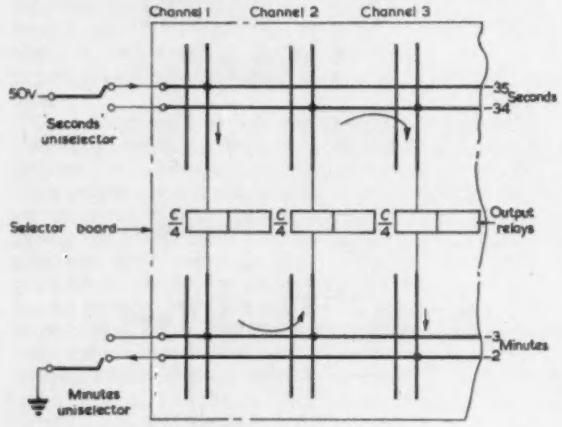


Fig. 5. Circuit diagram of selector board and output relays

Output relays connected to the vertical bars are switched on and off during the automatic run according to the positions of the studs inserted at the intersection of the conductor bars. As an example, the setting shown for channel 1 will cause relay *C* to switch on via the uniselectors at 2min 56sec before zero time; a second winding then holds *C* on until it is unlatched by relay *O* at 1min 55sec before zero time. The setting shown for channel 2 will result in the output relay switching on at 5sec and off at 1min 6sec after zero time. The rectifiers shown in the relay circuits block reverse currents that would occur with certain settings on the selector board, as shown by Fig. 6; these reverse currents would result in mis-timed operation of the relays.

Fig. 6. Fault current in relay circuit illustrating need for rectifiers
(All three relays will operate at the wrong time)



The uniselectors step automatically for a maximum period of 10min preceding the nominal zero time, i.e. the time at which the round is normally launched, followed by a 4min run to cover the flight of the missile. Time settings on the selector board are made with respect to zero time; a setting before zero having, conventionally, a negative value. It will be seen that a double annotation for the "Seconds", on the selector board, is necessary to suit both negative and positive settings.

Each output relay controls three contacts which switch pilot voltages to remote relays and contactors. Thirty output channels with three outlets on each are thus available so that a maximum of 90 remote equipments can be controlled. Manually operated switches are connected in parallel with the relay contacts, permitting the remote circuits to be controlled manually for test purposes. These

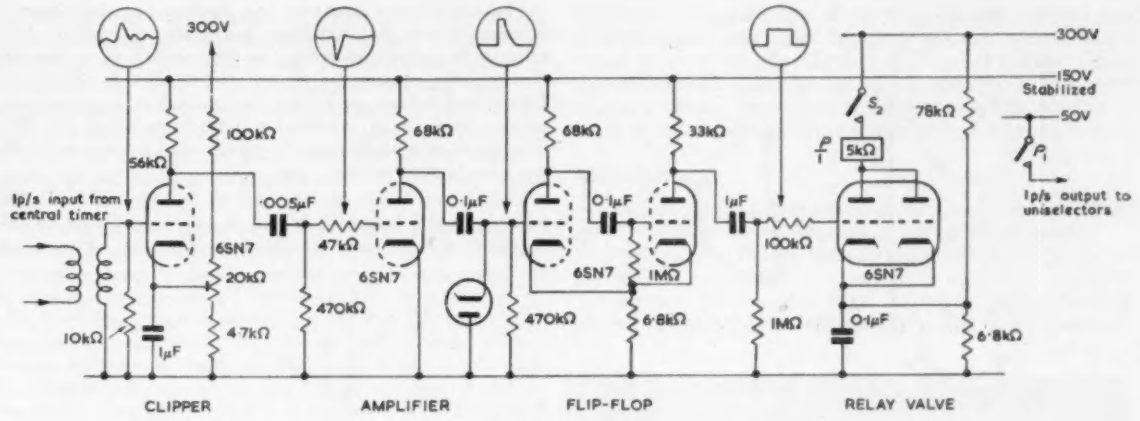


Fig. 7. Pulse amplifier

switches can be seen on the right-hand side of the console shown by Fig. 3. Ivorine labels are mounted beneath the switches so that they can be annotated according to the particular remote equipments which they control. The jumper panel shown on Fig. 5 permits remote circuits to be readily connected to any one of the 90 outlets so that maximum use can be made of the limited number of independently timed channels.

Pulse Amplifier

The function of the pulse amplifier is to amplify and widen the 1p/s pulses from the range central timer so that they operate a relay which steps the uniselectors. The pulses are transmitted from the remote timer over a long cable terminated at each end in balanced line transformers. A balanced line transmission is employed to eliminate the 'pick up' of extraneous signals that would cause mis-stepping of the uniselectors. The receiving end transformer is incorporated in the pulse amplifier.

The circuit, which is shown by Fig. 7, consists of a triode biased beyond cut-off to clip any small amplitude noise from the signal, followed by an amplifier and pulse widening flip-flop. The output of the flip-flop, which is a pulse of about 60msec duration, is fed to two triodes connected in parallel, with a relay in the anode circuit. This relay switches a voltage to the drive magnet of one of the uniselectors. The anode circuit of the relay valve is normally open, being closed by contact S_2 when the start switch is pressed to initiate the automatic operation of the programme switch.

The pulse amplifier, being a vital part of the equipment, is a self contained, plug-in unit with a built-in power pack. It can be quickly replaced with a spare in the event of a fault.

Uniselector Unit and Control Circuits

The uniselector chassis is illustrated by Fig. 8. Like the pulse amplifier it is a plug-in unit that can be replaced in the event of a fault.

Referring to Fig. 9; uniselector A is a special one having 30 outlets on each switch bank instead of the usual 25 ways. The wipers are staggered and the banks connected in pairs to give the required 60 outlets per revolution. It is stepped once per second by the pulsing of the relay P in the pulse amplifier. This operation commences when the control relays S and R are energized via the start switch and held on by the latching circuit through R_1 and S_1. Relay S switches on the relay valve in the pulse amplifier and R de-energizes the uniselector homing circuits. Operation of the stop switch releases S so that the uniselectors cease stepping, while operation of the reset switch releases both S and R so that the uniselectors halt and home to the start position ready for another run. Uniselector B is a standard 25 way unit, only 14 ways being required to complete the switching cycle. It is stepped by

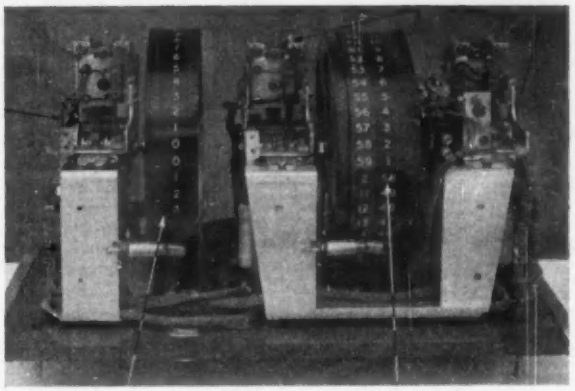


Fig. 8. Uniselector chassis

relay M which is energized once every 60sec by uniselector A.

The output connexions to the conductor bars of the selector board are made from the switching banks A_3, A_4 and B_2. It will be seen that the positive supply to these banks is fed via relay contacts R_2 and D_1. The contact R_2 isolates the outputs from the supply when the reset relay R is released; this ensures that there are no output voltages fed to the selector board as the uniselectors are homing. Contact D_1 protects the wipers by interrupting the supply while they are moving; it is operated by a slow release relay D which is pulsed by the signal from the pulse amplifier.

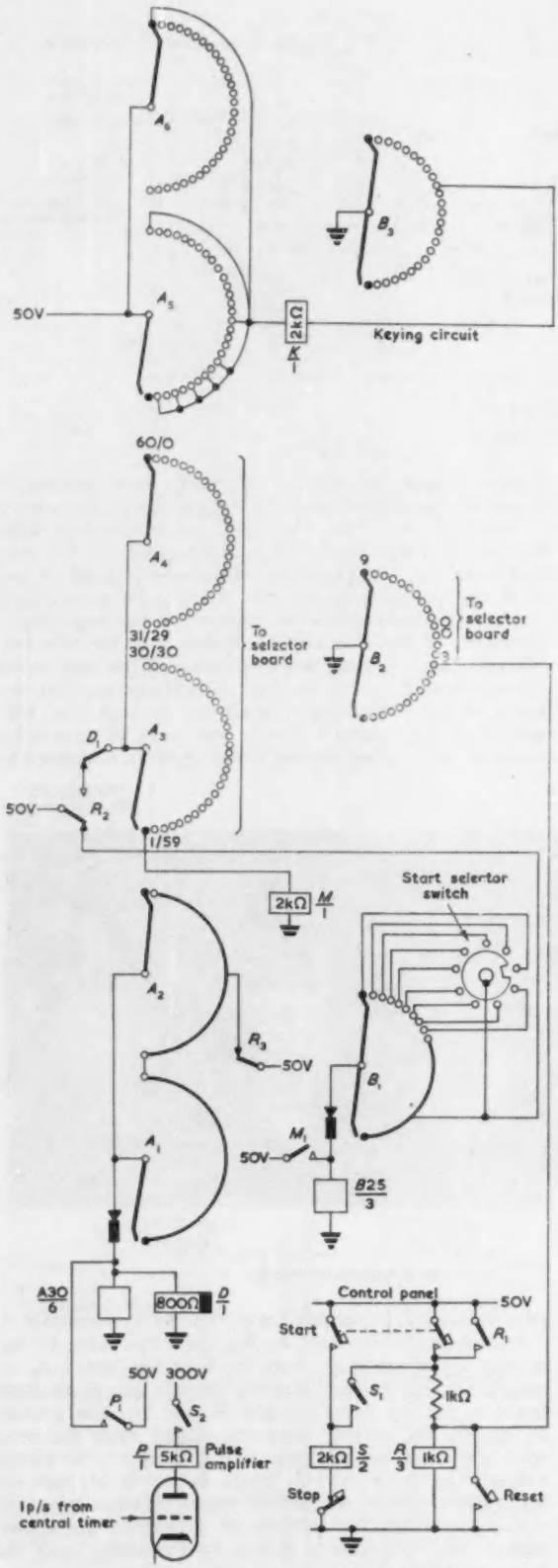


Fig. 9. Circuit diagram of uniselector chassis

The uniselectors home to the starting position, when R is released, on the switching banks A_1, A_2 and B_1. Uniselector B homes according to the setting of a shorting switch. This presets the uniselector so that it starts from 1 to 10min before zero time. At the end of a normal uniselector run, i.e. at +4min, an earth is switched via B_1 to trip the reset relay so that the uniselectors are automatically reset ready for the next run.

Uniselector banks A_5, A_6 and B_3 operate relay K. This relay keys the output valve of a 1kc/s oscillator so that warning 'peeps' are transmitted over the range inter-

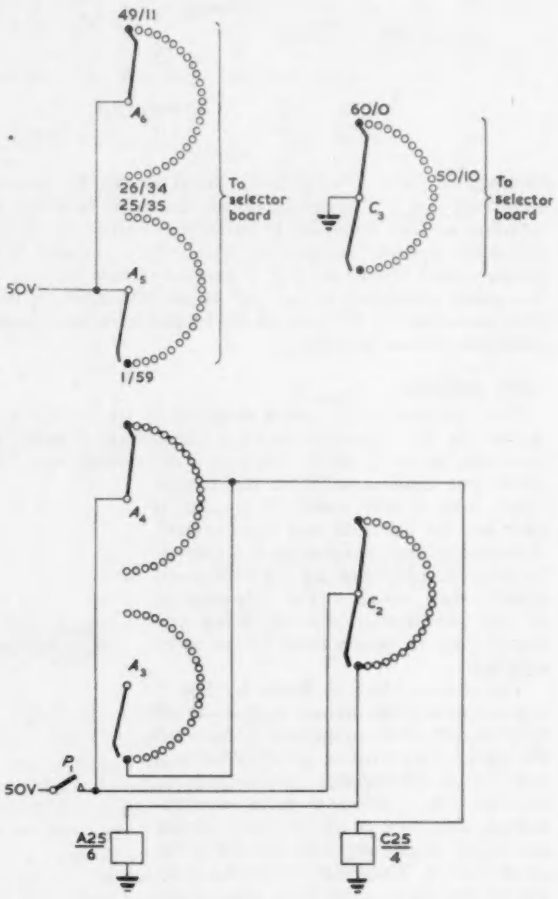


Fig. 10. Method of adapting two 25 way uniselectors to give a 60 way operation

communication system during the shoot. The time at which the 'peeps' are transmitted depends on the connexions to the uniselector banks; with the arrangement shown they are transmitted at −60, −30, −15, −10, −8, −6, −4 and −2sec before zero time. The outlets from the switch banks are wired to a small jumper board so that the time connexions can be easily altered if required.

Reference has been made to a non-standard, 30 way uniselector. While this is made it was not available when the programme switch was built and a circuit was improvised which permits the use of 25 way uniselectors. The circuits employing the 30 way uniselector has, however, been described in detail since it is the best arrangement

and illustrates the principle of operation most clearly. The method of using 25 way uniselectors to give the required 60 way operation is shown by Fig. 10. Two cross connected uniselectors are used; one providing 10 and the other 50 outlets. Uniselector *C* steps through the first 10 positions and completes the circuit to drive magnet *A*. Uniselector *A* then steps through the remaining 50 positions while *C* returns to its original position ready for the next 60sec cycle.

Indicator drums, engraved in minutes and seconds, are fitted to the uniselector spindles as illustrated by Fig. 8. They are viewed through a suitable aperture and count off the minutes and seconds of the operation with respect to zero time. The drums mounted on the two 'seconds' uniselectors are concentric; the inner drum being viewed through an aperture cut in the outer one. A single 'seconds' drum would suffice when using a 30 way uniselector. Negative time, i.e. time before zero, is engraved on a black and positive time on a red background. A double set of figures is engraved on the drums indicating seconds, corresponding to negative and positive time. The method of indicating time directly off the uniselectors ensures that the indication is always in phase with the switching operations; a false indication and announcement of time over the range intercommunication system would, of course, completely disorganize the shoot.

A requirement has arisen, since installing the programme switch, for time indication at a number of remote positions; various methods of meeting this are being considered. The problem is to adopt a simple method which will ensure that the indications are always in phase with the stepping of the programme switch. One solution is to wire a bank on each uniselector to function as a Desynn or Magslip transmitter, with two receivers at each remote position to indicate minutes and seconds.

Selector Board

This is illustrated by Fig. 11. It consists of a lattice of Inconel bars mounted on an insulating board. The bars are drilled and tapped so that that they can be connected at the intersections by screwing in 4 B.A. studs as shown. The horizontal bars on the rear of the board, which cannot be seen in the illustration, are in two groups; 60 of them are connected to the uniselectors stepping at second intervals and 14 to the uniselector which steps each minute. The bars on the front of the board are wired to the 30 output channels. The board is annotated in minutes and seconds according to the times the uniselectors switch to the horizontal bars. The times are repeated in four columns since it would be difficult to align studs against a single column across the whole width of the board.

Alarm Circuits

Failure or faulty operation of equipment in the missile and ground stations could result in a misfire or in the missile being launched with inadequate ground instrumentation in service. Alarm facilities are, therefore, provided so that during a shoot an operator at any of the remote stations can warn the control room if he is not satisfied with the operation of his equipment. The operator concerned presses a stop switch which sounds a buzzer and lights a warning lamp on the programme switch. The automatic operation is then interrupted or cancelled at the discretion of the programme switch operator.

The outlets of the programme switch are individually fused, primarily to protect the contacts of the output relays An automatic run with one or more of these fuses blown could result in a misfire or premature launching. It is therefore, important that a warning be given should any of these fuses blow either before or during a shoot. Alarm fuses, as used by the G.P.O., are therefore fitted. Each one consists of a contact spring anchored to a fuse wire. Rupture of the fuse wire releases the spring so that it contacts a common bus bar and energizes a warning buzzer.

Operation

The function of the programme switch is illustrated now by describing the procedure for an actual shoot.

A programme to suit the particular missile is set up on the selector board and any necessary alterations made to the jumper panel connexions. A typical programme is given by Table 1. The connexions to the remote stations

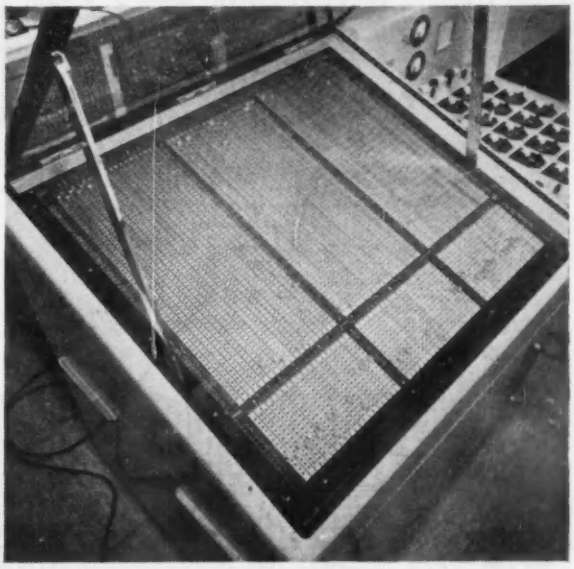


Fig. 11. Selector board

are then proved by operating the manual switches and checking that each equipment functions correctly and is connected to the right channel. Dangerous circuits such as those associated with the ignition of the rocket motor are checked as far as possible but voltage supplies are not completed to the equipment until all personnel are clear of the launching area prior to firing the missile. Safety links are then inserted and continuity checked with an ohmmeter.

The start selector switch is set to the time at which the automatic operation is to commence. For example, if the earliest setting on the selector board is −4min 30sec, the start selector will be set to −5min. The programme switch is now ready and the control officer stands by while final tests are made on the missile. If the programme is a complex one the firing is preceded by a dummy run. This duplicates the live run, as far as possible, to check the instrumentation and ensure that personnel are familiar with the procedure and ready for firing.

When all is ready, the launching area is cleared, the safety links inserted and final continuity tests made. The control officer alerts range personnel over the intercommunication system and presses the start switch. The operation then proceeds automatically while time is announced at suitable intervals. Apart from the time

announcements it is normal to maintain silence on the range intercommunication system so that it is free for emergency use. The sequence is interrupted in response to an alarm signal, or for any other reason, at the discretion of the control officer; the sequence continues when the start switch is pressed. If a failure in the instrumentation or the missile require the shoot to be cancelled, the reset switch is pressed. All remote circuits are then de-energized and the programme switch is ready for another run. The sequence normally continues to cover the flight of the missile and the uniselectors reset automatically.

at any time during a 24h cycle. The hour and minute selector switches of each channel are concentrically mounted with the switch pointers displayed against a clock face. A feature of the basic design which applies to this variation is the facility for operating a large number of independently timed channels off the two uniselectors. The number is limited only by the current rating of the uniselector wipers and outlets which supply the output relays.

A process control system using uniselectors has been described by Watson and Wiggs[2]. This system is of independent design to that described here; it is a good example of

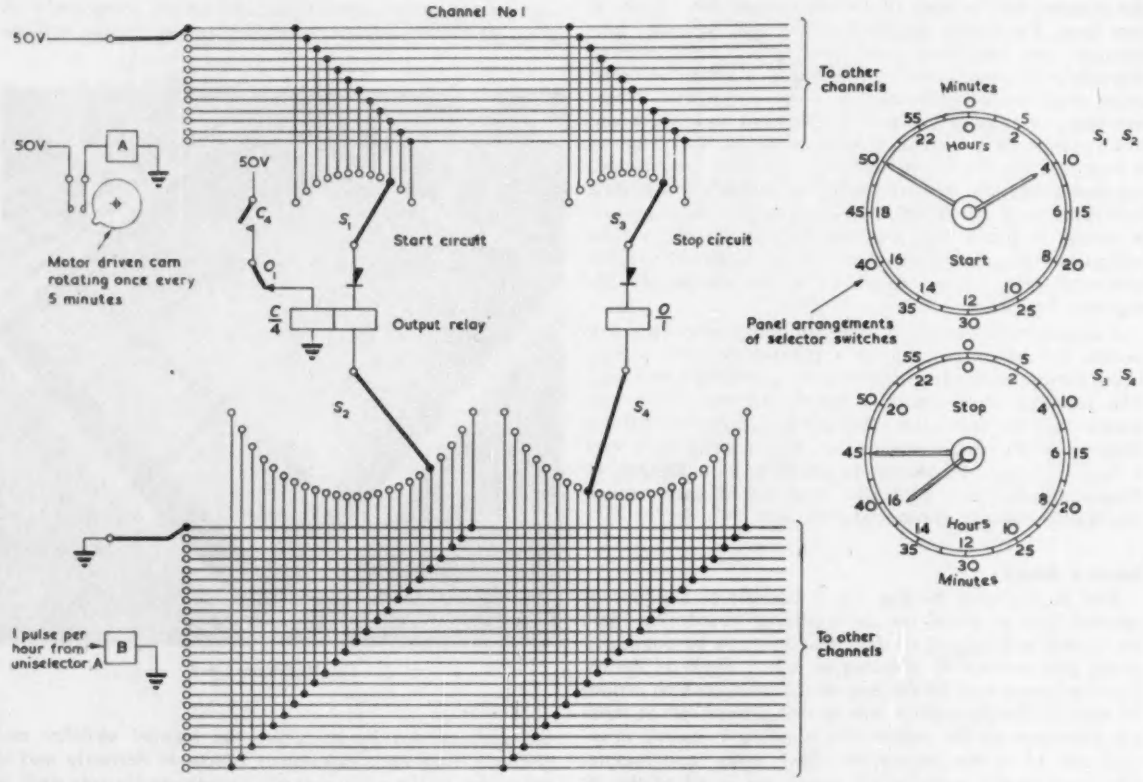


Fig. 12. Variation in basic circuit design

The time at which certain instruments should be switched off cannot be foreseen exactly since it depends on the behaviour of the missile during its flight. High speed cameras and recorders switched on by the programme switch are therefore switched off manually by local operators. This saves film which is used at the rate of 8ft/sec in some instruments.

Possible Developments

The equipment described was designed to meet specific requirements. However, the basic circuit could be readily adapted for other applications. An adaption, for example, that could be used for industrial process control is shown by Fig. 12. Here uniselector *A* is stepped every 5min and *B* every hour. Uniselector *A* is connected to recycle after every 12, and *B* after every 24, steps. Programmes are set up on a bank of multi-way switches which replace the selector board in this case. This arrangement permits equipments to be switched on and off, to the nearest 5min, the general application of automatic switching techniques.

The basic circuit could be adapted for firing operational missiles. The arrangement would be simpler in this case since the equipment would be designed to suit the limited requirements of a particular type of missile. Switches could be used to set up the firing programme. Alternatively a selector board would permit the use of ready-made programmes consisting of pre-arranged patterns of selector studs mounted on plug-in panels.

Acknowledgments

A prototype of the programme switch was originally designed in the Guided Weapons Department of the Royal Aircraft Establishment. The equipment described, however, is the result of subsequent development and engineering by the Plessey Manufacturing Co. Ltd.

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Junction Transistor Sawtooth Waveform Generators

By K. P. Padmanabhan Nambiar, M.Sc., D.I.C.

The bootstrap and Miller integrators are two well-known thermionic valve circuits for generating linear sweeps or sawtooth waveforms. In this article these circuits and their equivalents using junction transistors are discussed. It is shown that sufficient current swing can be obtained for applications such as electromagnetic scanning of miniature television camera tubes using currently available low power transistors.

TWO well-known circuits in valve practice for generating linear sweeps or sawtooth waveforms are the Miller and the bootstrap integrators. The two forms of circuit are very similar in operation and differ mainly in the choice of earthing points. It is found that junction transistors may be successfully employed in either of the two forms of circuit to generate linear sweeps, the percentage non-linearity in either case being less than 1 per cent in certain circuits[1]. In the following, circuits of the bootstrap type, recurrently generating sawtooth voltages and currents, are discussed; it is shown that the current and voltage swings are limited mainly by the dissipation rating of the transistor. Sufficient current swing for applications such as electromagnetic scanning of miniature television camera tubes (for example, vidicon photo-conductive tube), may be obtained with currently available low power transistors of the OC72 type.

Generation of Linear Sweeps

The action of the bootstrap circuit using either a junction transistor or a valve may be seen by reference to Fig. 1. In Fig. 1(a), X_1 is an emitter-follower similar to the cathode-follower V_1 of Fig. 1(b), and exhibits a voltage gain, A, close to unity, from the base to the emitter load R_e. Assume that the switch S is closed in the steady state and then suddenly opened. The diode D_1 conducts and a current I flows into the capacitor C (which is initially at earth potential) building up a voltage V_1 across it. For a pnp transistor the supply voltage is actually negative so that I flowing into C, and the potential V_1 built up across C, are also negative quantities. The action of the valve circuit follows very closely to the bootstrap circuit using an npn transistor where the polarities of voltages and currents are all positive. Owing to the emitter-follower action, an output voltage $V_o = AV_1$, appears at the emitter of X_1; if the feedback capacitor C_1 is so large that it offers negligible impedance to the potential changes at the emitter of X_1, V_o will appear at the anode of D_1, cutting off the diode. Since the feedback capacitor C_1 is charged to the supply potential V_e in the steady state this acts as a 'floating battery' supplying the current which flows into the charging capacitor C, while at the same time maintaining the feedback of V_o to the junction of the resistor R and the diode D_1. These two functions performed by the capacitor C_1 enable a continuous supply of charging current I to flow. This current would be a constant and equal to V_e/R, if A were unity, R_1 infinite and the output resistance of the emitter-follower zero; the voltage built up across the capacitor C would then be a perfectly linear sweep.

In practice the voltage V_1 developed across the capacitor, and consequently the output voltage V_o, is non-linear owing to the voltage gain A being less than unity and the input resistance R_1 of the emitter-follower having a finite though large value. Both these factors alter the magnitude of the current I through C. For any value of V_1 corresponding to time considered, a value of A less than unity reduces the magnitude of the current flowing into the capacitor C from V_e/R to $[(V_e/R) - V_1(1-A)/R]$. V_1 may be assumed to be an approximately linear sweep if the change in the current I is relatively small so that

$$V_1 = (V_e t/CR) \quad \ldots\ldots\ldots\ldots\ldots \quad (1)$$

The decrease in current through C at any time owing to non-unity gain is then given by

$$\frac{V_e t}{CR} \quad \frac{(1-A)}{R}$$

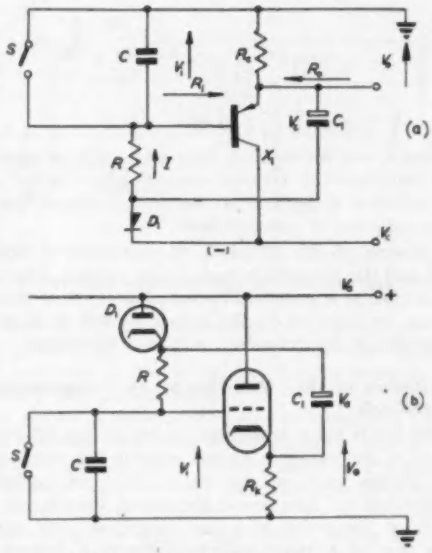

Fig. 1. Bootstrap linear sweep circuits
(a) Circuit using junction transistor
(b) Circuit using triode valve

The magnitude of the current flowing into C is also decreased from the initial value of V_e/R because of diversion of current into the base of the transistor, this decrease being dependent on the input resistance R_1. Thus again assuming V_1 to be a linear sweep as above the decrease in current due to R_1 is given by

$$V_1/R_1 = (V_e t/CRR_1)$$

The total decrease in current ΔI through the capacitor C in relation to time is therefore

$$V_e t/CR\left[\frac{(1-A)}{R} + (1/R_1)\right]$$

The reduction in voltage across C due to this current is given by

$$V_d = (1/C)\int \Delta I \,.\, dt =$$

$$\frac{V_e}{2\,.\,CR\,.\,CR}\,[(1-A) + (R/R_1)]\; t^2 \ldots \quad (2)$$

The degree of non-linearity may be expressed as the deviation of the instantaneous output voltage of the actual sweep from the instantaneous voltage of an assumed straight line which closely represents the actual sweep. This deviation is expressed as a percentage of the actual sweep and is termed 'displacement error' or percentage non-linearity, denoted here by ϵ. The straight line is assumed to coincide with the beginning of the sweep and have a slope equal to the initial slope of the actual sweep. If the switch S of Fig. 1 is closed at a time duration $t = t_s$, the voltage across the capacitor C will consist of a linear sweep V_s equal to $V_c t_s/CR$, and a distortion term due to V_d, given by equation (2), where t_s is substituted for t. The percentage non-linearity is then given by the ratio of V_d and V_s so that

$$\epsilon = (V_d/V_s) \times 100 = (50t_s/CR)\,(\delta + k) \text{ per cent} \quad \ldots\ldots (3)$$

where $\delta = 1 - A$ and $k = (R/R_i)$.

In terms of the small signal a.c. parameters of the junction transistor

$$A = \frac{R_e}{r_e + R_e + r_b(1 + A_i)} \quad \ldots\ldots\ldots (4)$$

where

$$A_i \simeq \frac{\alpha r_c}{R_e + r_c(1 - \alpha)} = \frac{\alpha}{(1 - \alpha) + R_e/r_c} \quad \ldots\ldots (5)$$

so that

$$\delta = (1 - A) \simeq \frac{r_e + r_b/(1 + A_i)}{R_e} \quad \ldots\ldots (6)$$

and

$$R_i = r_b + R_e(1 + A_i) \quad \ldots\ldots\ldots\ldots (7)$$

r_e, r_b and r_c are the emitter, base and collector resistances, α, the short-circuit current amplification factor of the grounded base stage, and A_i the circuit current gain from base to collector of the transistor.

On closing of the switch S the capacitor C discharges rapidly and the potential across it falls to zero. The rapidity of the discharge is governed by the magnitude of the current that may be supplied by the switch S—which, in the practical circuits to be described, is also a transistor.

Linearization of the 'Run-Down' by Compensating Feedback

In the triode valve bootstrap circuit of Fig. 1(b) the non-linearity of the sweep is almost entirely the result of non-unity voltage gain A; the value of k of equation (3) approximates to zero since the input impedance of the valve is of the order of many megohms. The maximum voltage gain of a triode cathode-follower is defined by the amplification factor μ of the valve so that

$$A < (\mu/(\mu + 1))$$

In the junction transistor emitter-follower circuit the voltage gain $A = (A_t/(1 + A_t))$, where A_t is the voltage gain of a grounded emitter stage with R_e as its collector load. This voltage gain A_t is given by $A_i \,.\, (R_e/R_{in})$, where R_{in} is the input resistance of the grounded emitter stage. In practice the magnitude of the amplification factor μ of the triode valve is only of the order of the current gain A_i of the transistor so that by increasing the ratio of R_e/R_{in} within limits by appropriate choice of R_e the voltage gain A may be made much closer to unity in the case of the emitter-follower than for the triode cathode-follower.

For example, the current gain A_i of a transistor may typically be equal to 40 with $R_e = 10\text{k}\Omega$ and $R_{in} = 1\text{k}\Omega$.

Then $A_t = A_i \,.\, (R_e/R_{in}) = 400$

so that $A = (A_t/(1 + A_t)) = 400/401 = 0{\cdot}997$ for the emitter follower.

Assuming a value for μ, equal to that for A_i, in the valve case, the voltage gain A of the triode cathode-follower will be equal to or less than 40/41 so that $A \leqslant 0{\cdot}976$ for the cathode-follower.

Thus the approximation of A to unity is much more valid for the emitter-follower than for its valve counterpart.

However, due to the resistive path between the base and the emitter and the finite value of the current gain A_i the approximation of R_i to infinity is not valid in the emitter-follower and this is mainly responsible for the non-linearity in the generated sweeps.

In valve circuits, the sweep non-linearity resulting from departure of A from unity may be considerably reduced by a resistive feedback method of compensation[2]. Fortunately, this compensation technique is valid[1] regardless of the cause of non-linearity provided it be largely attributed to the t^2 term given in equation (2), so that effective compensation for the finite value of R_i and for the non-unity

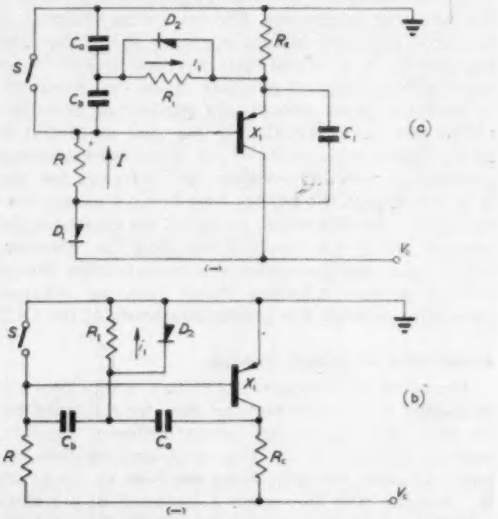

Fig. 2. Resistance compensation for the improvement of sweep linearity
(a) Bootstrap
(b) Miller

gain A of the junction transistor circuit is feasible. The method of compensation is illustrated in Fig. 2(a). Here the charging capacitor C is split into two, C_a and C_b and a resistor R_1 connected between the junction of the capacitor and the emitter of X_1. The potential difference across R_1 drives a current i_1 through it; assuming this is linear with time t, a 'compensating' potential proportional to t^2 will be developed at the base of X_1 as a result of integration of i_1; this integration is performed mainly by C_a because of the relatively high resistance paths (i.e. via R or R_i) associated with the charging of C_b. This compensating potential is in opposite phase to the initial distortion term of equation (2) and the magnitude may be made equal to the initial distortion by appropriate choice of R_1.

Assuming $C_a = C_b$, R_1 is given by the relation

$$R_1 = \frac{R}{4(1 - A + (R/R_i))}$$

If $(1 - A) \ll R/R_i$ as is usual in emitter-follower circuits

$$R_1 = (R_1/4) \simeq \frac{R_e(1 + A_i)}{4}$$

In the Miller* version of the sweep circuit the compensating resistor R_1 may be connected between the junction of

* *This form of compensation for Miller sweep circuits does not appear to have been mentioned in any literature; by employing this compensation, however, the linearity of Miller circuits using valves or transistors may be considerably improved.*

the capacitors and earth as shown in Fig. 2(b). The value of R_1 is then given by $R_c(1 + A_1)/4$, where R_c is the collector load resistance.

In practice a potentiometer may be employed for R_1 and used as a linearity control. The diode D_2 is non-conducting throughout the sweep and helps to reset the potential at the junction of C_a and C_b at the end of the flyback.

RECHARGE OF C_1

In all bootstrap circuits C_1 acts as a 'floating battery' during the sweep, supplying current for integration by the charging capacitor C and consequently loses some of its charge in the process. In valve circuits the charge lost is considerably smaller owing to the large value that can be employed for R (since $R_1 \rightarrow \infty$) thereby reducing the charging current supplied by C_1. In the transistor circuit, however, for good linearity the value of R should be relatively low and much smaller than the finite value of R_1 so that much larger currents flow during the sweep. Consequently the charge lost by C_1 may become appreciable and C_1

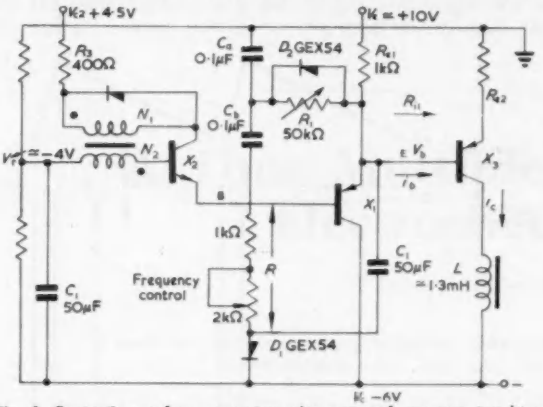

Fig. 3. Sawtooth waveform generator using pnp and one npn transistors.
The value of R_{e2} defines the maximum current swing through L, X_1 and X_2: Type OC72 (cooling fins fixed to the metal chassis or appropriate heat sink) X_2: npn GD2517. R_{e2} as required but not less than 27Ω. Blocking oscillator transformer: core: potcore type LA1, N_1 — 250 turns, N_2 — 125 ,, } 40 s.w.g.
Frequency of operation — 10kc/s

should be recharged before commencing the subsequent sweep. This may be done by a current drawn via the output of the emitter-follower or via R_e from a positive supply voltage V_e or by the addition of a transistor switch at the emitter of X_1, the switch being in the cut-off state during the 'run-down' and 'on' state during the flyback; in the 'on' state large currents may be made available for the recharge of C_1.

As stated earlier the base of the transistor X_1 returns to the steady state (earth potential) by the current supplied by the switch S.

Sawtooth Voltage and Current Generator Circuits

Fig. 3 shows a form of sawtooth generator-employing junction transistors. Here X_1 acts as the emitter-follower and X_2 as the switch S of Fig. 1. X_2 is an npn transistor and is initially held cut off by a negative reference potential V_r at its base; the bootstrap action and linear 'run-down' occur as discussed previously until the potential at the base of X_1 (i.e. V_1) approaches V_r. When $V_1 \simeq V_r$ emitter current begins to flow in X_2, the current increasing regeneratively owing to the blocking oscillator action until limited by the resistor R_2. X_1 is thus in the 'on' state supplying large currents for the discharge of the charging capacitor C_a and C_b so that the base of X_1 recovers to earth potential. At the same time the emitter potential of X_1 rises and recharge of C_1 is also completed aided by the current supplied via R_e. At the end of the flyback X_2 is again cut off so that the 'run-down' process is repeated. Thus a recurrent sawtooth voltage waveform appears across the emitter load R_{e1} of X_1.

X_3 stage in Fig. 3 converts the voltage sweep into current sweep, as discussed in more detail later, the linear rise in current being obtained through the coil L and the peak swing defined by the value of R_{e2} in the emitter of X_3. Using type OC72 transistors for X_1 and X_3 (with their cooling fins connected to a heat sink) a current swing up to 150mA has been obtained through the coil as R_{e2} is decreased to 27Ω, the run-down and flyback periods being of the order of 94 and 6μsec respectively, corresponding to a television line scanning frequency of approximately 10kc/s. The linearity of the scan is adjusted by the potentiometer R_1. Non-linearity present is mainly due to insufficient compensation for the variations of the current amplification factor α of X_3 and in parameters of X_1 during the sweep. The parameter α falls off with increasing emitter current, $(1 - \alpha)$ being roughly proportional to the emitter current at high currents so that the effective a.c.

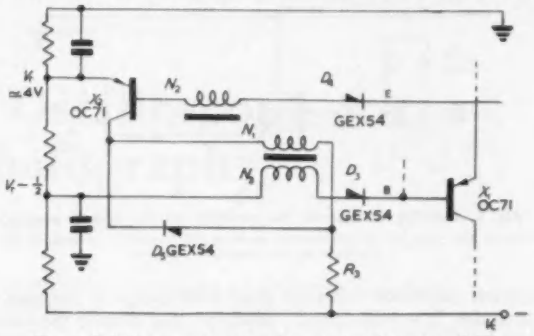

Fig. 4. Switching arrangement using pnp transistor type OC71

emitter load resistance of X_1 varies correspondingly resulting in variations of R_1 and A of X_1. Distortion limited to about 1 per cent or less is estimated to be possible in all the practical circuits discussed.

Fig. 4 shows a somewhat different switching arrangement for a circuit employing a pnp transistor for X_2. Here the emitter of X_2 is initially at the negative reference potential V_r so that X_2 is cut off, the current I flows through R into the integrating capacitor C_a and C_b of the bootstrap circuit initiating the linear 'run-down'. When the sweep amplitude V_s appearing at E (Fig. 4) equals V_r, emitter current flows in X_2 and the blocking oscillator fires. The diode D_3 is reverse biased throughout the sweep by returning one end of the winding N_3 to a potential negative to V_r by at least half a volt; this biasing prevents the conduction of D_2 before the firing of the blocking oscillator comparator. During the pulse large collector current flows in X_2, a portion of this current being transferred for the discharge of the capacitors connected at the point B via the winding N_3 of the pulse transformer, the diode D_3 conducting in the process. Apart from the presence of an additional winding for the pulse transformer and two extra diodes D_3 and D_4 the switching arrangement of Figs. 3 and 4 are very similar. D_4 prevents any negative 'spike' appearing at the emitter of X_1 when the regenerative action of X_2 ceases.

In the above circuits synchronization may be achieved by applying the synchronizing pulses at the base of X_2. There are applications, however, where a recurrently driven circuit is more suitable than an oscillatory one. In that case, the transformer may be eliminated and X_2 functions

as an externally driven switch as shown in Fig. 5. Here X_2 is held cut off by a positive voltage V_b at the base so that the sweep action in X_1 proceeds as already discussed. When the period of the run-down equals the required period of the active scan a negative going pulse is applied at the base of X_2; large collector current flows in X_2 discharging the capacitors C_a and C_b connected at the point B, to earth potential. On removing the pulse, the base of X_2 returns to the positive potential set by V_b and X_2 is cut off initiating the subsequent run-down.

It should be noted that, in all the circuits discussed above, the sweep amplitude at B cannot exceed $V_c R_1/(R + R_1)$, the potential drop across R_1 in the absence of C.

Conversion of Voltage into Current Sweeps

Normally in valve circuits sawtooth voltages of the order of 3 to 5V applied to the grid will be quite inadequate to produce any appreciable linear current rise in an inductance placed in the anode of the valve owing to the non-linearity of the transfer characteristics, resulting in variation of g_m and also due to the approximation to a constant

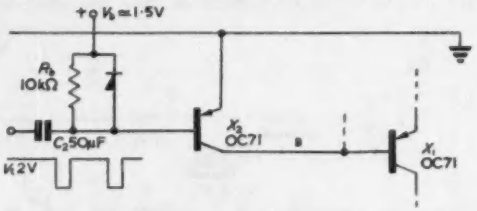

Fig. 5. Switching arrangement for externally driven sawtooth generator
Note in this case the potentiometer forming the frequency control of Fig. 3 functions as an amplitude control

current generator being far from true except in the case of pentodes. It would appear, however, that despite the variation in the current gain A_1 with increasing emitter currents, the transistor is very well suited to transform linear voltage sweeps of relatively low amplitudes into large current sweeps, the peak current swings being readily defined by the emitter resistance R_{e2} (Fig. 3) employed in the circuit. With reference to Fig. 3 stage X_2

$$(i_c/i_b) = A_1$$

and $R_{11} = R_{e2}(1 + A_1)$

The base current i_b due to the sweep voltage V_b at the base of X_2 is given by

$$i_b = \frac{V_b}{R_{e2}(1 + A_1)}$$

so that $i_c = i_b \cdot A_1 = (V_b/R_{e2}) \cdot \frac{A_1}{(1 + A_1)} \simeq (V_b/R_{e2})$

assuming $A_1 \gg 1$.

Thus the collector current X_2 is largely independent of the current gain A_1, provided V_b is unaltered by variations in R_{11} and

$$R_{e2}(1 + A_1) \gg r_b + (1 + A_1) r_e$$

or

$$R_{e2} \gg \frac{r_b}{1 + A_1} + r_e$$

(The short-circuit output resistance of the X_2 stage).

r_e is quite negligible for emitter currents of a few milliamperes or more so that R_{e2} of a few tens of ohms would be adequate to satisfy this condition.

However, the variations in input impedance of X_2 stage due to variation in α alters the dynamic emitter load resistance of the emitter-follower X_1, changing the magnitude of its R_1 thereby distorting the sweep. This effect will be relatively insignificant provided

$$R_{e1} \ll A_1 . R_{e2}$$

where A_1 corresponds to the current gain of X_2. Thus provided R_{e1} and R_{e2} are chosen to satisfy the above requirements a single stage transistor (such as X_2 stage) can affect the conversion of sawtooth voltage into current with good accuracy.

Application to Electromagnetic Scanning

The coil L in Fig. 3 represents the effective value of the inductance in the collector circuit of X_3; the scanning coil

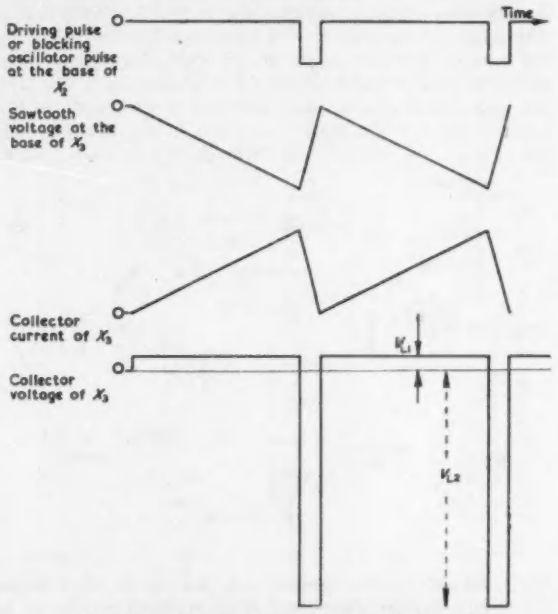
Time
Driving pulse or blocking oscillator pulse at the base of X_2
Sawtooth voltage at the base of X_3
Collector current of X_3
Collector voltage of X_3
V_L1
V_L2

Fig. 6. Idealized waveforms of the circuits discussed

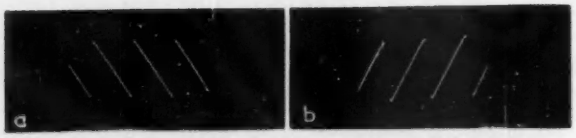

Fig. 7. Base voltage and collector current waveforms of X_3

itself is not normally placed in the collector circuit in order to avoid the positional shift encountered in the circuits having a d.c. voltage path. The value of the effective inductance that may be employed will depend upon the rate of change of current during the flyback owing to large negative voltage appearing at the collector during this period.

The dynamic collector voltage V_L of X_3 consists of two components V_{L1} during the 'run-down' and V_{L2} during the flyback where

$$V_{L1} = L(di/dt) = L . (I_a/t_a) \text{ volts}$$

and $V_{L2} = L(di/dt) = -L . (I_a/t_f)$ volts

where I_a is the peak sweep current through the collector of X_3, t_a and t_f the scanning period and flyback period respectively. If the scanning period is very much greater than the flyback $V_L \simeq -L(I_a/t_a)$.

Thus the inductance L of the coil in the collector of X_3 is limited by the maximum negative voltage permissible across the collector junction during the flyback and the rate of charge of the flyback current. In the circuits dis-

cussed above the effective value of L is just over 1mH being the inductance of scanning coils suitable for line scanning of a vidicon camera tube. For a flyback period of 6μsec and a maximum swing of 150mA, V_L is of the order of -30V.

Idealized waveforms are shown in Fig. 6 and the oscillograms of the actual waveforms of the base voltage and collector current of X_3 are shown in Fig. 7.

Thus where scanning current requirements are relatively low, current sweeps for magnetic deflexion may be generated by the circuits described above. It must be mentioned, however, that a value of 27Ω for R_{e2} is almost the limiting case for an OC72 type transistor, 150mA swing dissipating nearly its peak rated power. The conditions governing the choice of R_{e2} and R_{e1} are better satisfied by higher values for R_{e2} thereby limiting current swings in the circuits described. The variations of input impedance and voltage gain of the bootstrap sweep generator stage and the dissipation and maximum collector voltage ratings of the output stage are the main limitations to the quality and magnitude of the current sweeps. Owing to the need to replenish the charge lost by the feedback capacitor C_1 during the sweep before the subsequent sweep can commence, very high repetition rates cannot be achieved in the bootstrap type circuit which appears to be its basic disadvantage. The effect of variation in the collector cut off current I_{co} due to temperature is negligible in circuits where the charging current I is relatively very much higher. For a temperature range of 20 to 50° C, the variation in I_{co} for the above transistors was found to be less than 50μA.

Acknowledgments

In preparing this article the author has made use of some of the information and diagrams in the paper entitled "Junction Transistor Bootstrap Linear Sweep Circuits" by himself and Dr. A. R. Boothroyd, which was first published by the Institution of Electrical Engineers as Paper No. 2228R in January 1957 and republished in Part B of the Proceedings of that Institution.

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A Time-Multiplex Oscilloscope for Electroencephalography

By T. J. McDermott*, M.Sc., A.R.C.S.

A small instrument has been designed, using pulse time multiplex techniques, to amplify and display simultaneously on one c.r.t. six electroencephalographic potentials.

As part of a programme of investigation of the use of pulse time multiplex techniques for the simultaneous amplification and display of a number of electrophysiological potentials, it was decided to design a small instrument for early diagnostic purposes in electroencephalography. The use of the multiplex techniques entailed the use of a cathode-ray tube for presentation of the e.e.g. signals. It was considered, however, that a small inexpensive instrument which could display six channels of e.e.g. information on the screen of a c.r.t. with an after-glow phosphor would be quite useful for some e.e.g. purposes. The following instrument was designed and a laboratory model made, so that trials of its diagnostic value could be held.

The display of six e.e.g. signals on one c.r.t. was achieved by the use of a seven step echelon waveform of approximately 1msec period to produce a vertical deflexion of the trace to each of seven spots. From the echelon waveform six pulse trains, individually derived from each of the six steps, are used as pulse carrier of the e.e.g. signals. The separate amplitude modulated pulse trains are combined and amplified in the 'slicer-amplifier' and the amplified pulses elongated. These elongated amplitude-modulated pulses are added to the echelon waveform. Thus each spot of the c.r.t. trace has a vertical deflexion, proportional to a channel signal. A slow time-base which can be either repetitive or triggered by some external means, is applied to the X plates of the c.r.t. Thus the deflexions of the six spots are traced out across the face of the c.r.t. at speeds corresponding to those at which a normal e.e.g. records on paper. The record, of course, is visible only for a few seconds at a given time, and the operator has to make judgments of the nature of the record in that time.

The shortness of the time available for judgments to be made, suggested a departure from standard e.e.g. practice, that was used in the prototype. The localization of foci in e.e.g. practice depends on the recognition of 'phase reversals' in the bipolar recording. It was considered that such phase reversals would be very difficult to identify on the c.r.t. screen, so the system of unipolar recording with an 'electrical mean reference potential' was used. With such a system, foci would be identified by voltage maxima, and it was considered that this would be more satisfactory in practice.

Circuit Design

The Time Division System

The c.r.t. used was the DP13-2 a 6in diameter electrostatic deflexion tube, with a long persistence phosphor, and post deflexion acceleration.

A block diagram of the overall system is shown in Fig. 1 and a detailed circuit diagram in Fig. 2. Valve V_{E1} is a master-oscillator controlling the 10kc/s pulse repetition frequency of the whole system. The oscillator transformer T_{E1} has a secondary winding across which a 10kc/s sine wave of 2·0kV is developed. Two e.h.t. voltages of + 2·5kV and − 1·7kV for the post deflexion accelerator anode, and cathode of the c.r.t. are produced by rectifiers 36eht 100 and the reservoir capacitors C_{E22} and C_{E24}. The oscillation (Fig. 3(a)), fed through diode V_{B2a}, is also used to control the frequency of the blocking oscillator V_{B1}, which produces a train of short pulses at the 10kc/s repetition frequency (Fig. 3(b)). The duration of these short

* *Neuropsychiatric Research Centre, Whitchurch Hospital, Cardiff.*

pulses is determined by the short-circuited section of the delay line DL and their amplitude is limited by the diode V_{B2b}. The pulses produced in the cathode of V_{B1} are delayed by the section of the delay-line terminated by R_{B13}. The pulses occur across R_{B13} 1·5μsec after the current pulse in the anode resistor R_{B14}. This delay is necessary for the operation of the pulse amplitude detector system V_{A4} and V_{A5}.

From the train of 1μsec pulses developed across R_{B13}, an echelon waveform (Fig. 3(d)) of seven steps of period 700μsec is derived by the transitron controlled Miller-integrator V_{B4}. The echelon waveform appearing across the anode load resistors R_{B43} and R_{B44} is limited in the positive and negative directions by the diodes $V_{B5a,b}$. The third anode of the c.r.t. is taken to the junction of R_{B51} and R_{B52}, so that its potential is the mean potential of the anode of V_{B4}. The echelon waveform developed at the anode of V_{B4} is inverted by the anode-follower V_{B6}, and the Y plates of the c.r.t. are connected to these two anodes to produce a symmetrical deflexion of the c.r.t. spot.

A fraction $\frac{R_{B43}}{(R_{B43}+R_{B44})}$ of the echelon waveform developed at the anode of V_{B4} is fed via the cathode-follower V_{B7} to the anodes of the slicing diodes V_{K4b}. Resistors R_{K42} are returned to a sequence of tappings on a long resistance chain made up of the parallel series combination of resistors R_{K43} and R_{K44} with R_{K45-49}. These tappings are at the potentials V_{n1}-V_{n6} indicated in Fig. 3(d). The diodes V_{K4b} slice the echelon applied to their anodes to develop waveforms such as those shown in Fig. 3($e_{3,4}$). The anodes of diodes V_{K4a} are returned via resistors R_{K41} to the sequence of potentials V_{n1-6}, and thus pulses, whose negative going edges correspond to the steps of the echelon waveform are produced across resistor R_{K41} as shown in Fig. 3(f,i). These pulses are differentiated and inverted by capacitors C_{K32} and ferroxcube pulse transformers T_{K1} to produce the channel pulses (Fig. 3(g,j)). These latter are applied to the grids of the channel modulator triodes V_{K3} in addition to the channel signal that is developed across resistor R_{K31}. Thermionic diodes type EB91 were used for the slicing diodes $V_{K4a,b}$ since point-contact germanium diodes were found to have a large low frequency random variation of their back-resistance.

The modulator triodes V_{K3} are maintained biased beyond cut off by the voltage across R_{A11} in the cathode of pentode V_{A1}. Each triode V_{K3} only conducts for the duration of the positive-going channel pulse applied to its grid, and then in conjunction with pentode V_{A1}, forms a long-tail pair of amplifiers. The current pulses developed in the cathode of channel triodes V_{K3} are separately amplitude modulated by the channel signals applied across resistors R_{K31}, from these pulses, positive voltage pulses are produced across the anode resistor R_{A12} of valve V_{A1}. These pulses are amplified in valves V_{A2} and V_{A3}. For this purpose double triodes are used as long-tail pair amplifiers. By their use the pulses are maintained as positive-going pulses applied to the input grids, which are negatively biased well beyond 'cut-off'. It is essential to avoid the flow of grid current in the slicing circuits, as the variation of the mean potentials which would result from the amplitude modulation of the pulses would introduce inter-channel cross-modulation. Consequently, the transfer of negative going pulses through a capacitance-resistance coupling with the slicing achieved by the flow of grid-cathode or diode current, is to be avoided. The interstage coupling has a time-constant of approximately 20μsec, sufficiently long to produce little distortion of the pulse shape, but short enough that the cross-modulation produced by the pulse tail is negligible. The balanced current taken in the long-tail pair reduces the difficulties of feedback to the common load resistance of the power pack, and no decoupling is necessary.

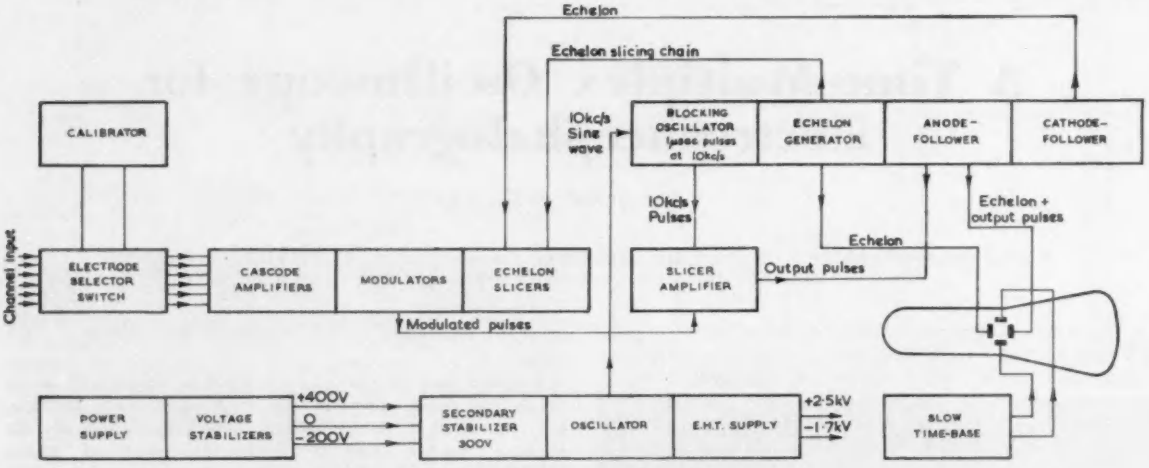


Fig. 1. General arrangement of the instrument

The amplified pulses are fed to the 'pulse amplitude detector' V_{A4}. The positive-going pulses from the anode of V_{A3} (Fig. 3(h)) are fed to the grid of the cathode-follower V_{A4a}. A capacitor C_{A42} is connected as the cathode load of V_{A4a} as is also the grid of cathode-follower V_{A4b}. So long as C_{A42}/g_m is small compared with the duration of the applied pulse, the capacitor is charged to the peak potential of the applied pulse and remains so charged. At the end of a channel interval, a negative pulse, from the anode of V_{B1} is applied to the capacitor C_{A42} through the diode V_{A5a}. The capacitor is thus discharged to a fixed negative potential 1·5μsec before the next channel pulse arrives to recharge it. Thus the output voltage across the cathode load R_{A4} of cathode-follower V_{A4b}, is maintained for the 100μsec channel interval, at the peak potential of the channel pulse. The resultant pulse train is illustrated in Fig. 3(i). This pulse train is added to the echelon waveform by the grid resistance network $R_{B61,62,63,64\,65}$, of the anode-follower V_{B6}. Consequently the vertical deflexion of each spot of the c.r.t. will be proportional to the amplitude of the appropriate channel pulse.

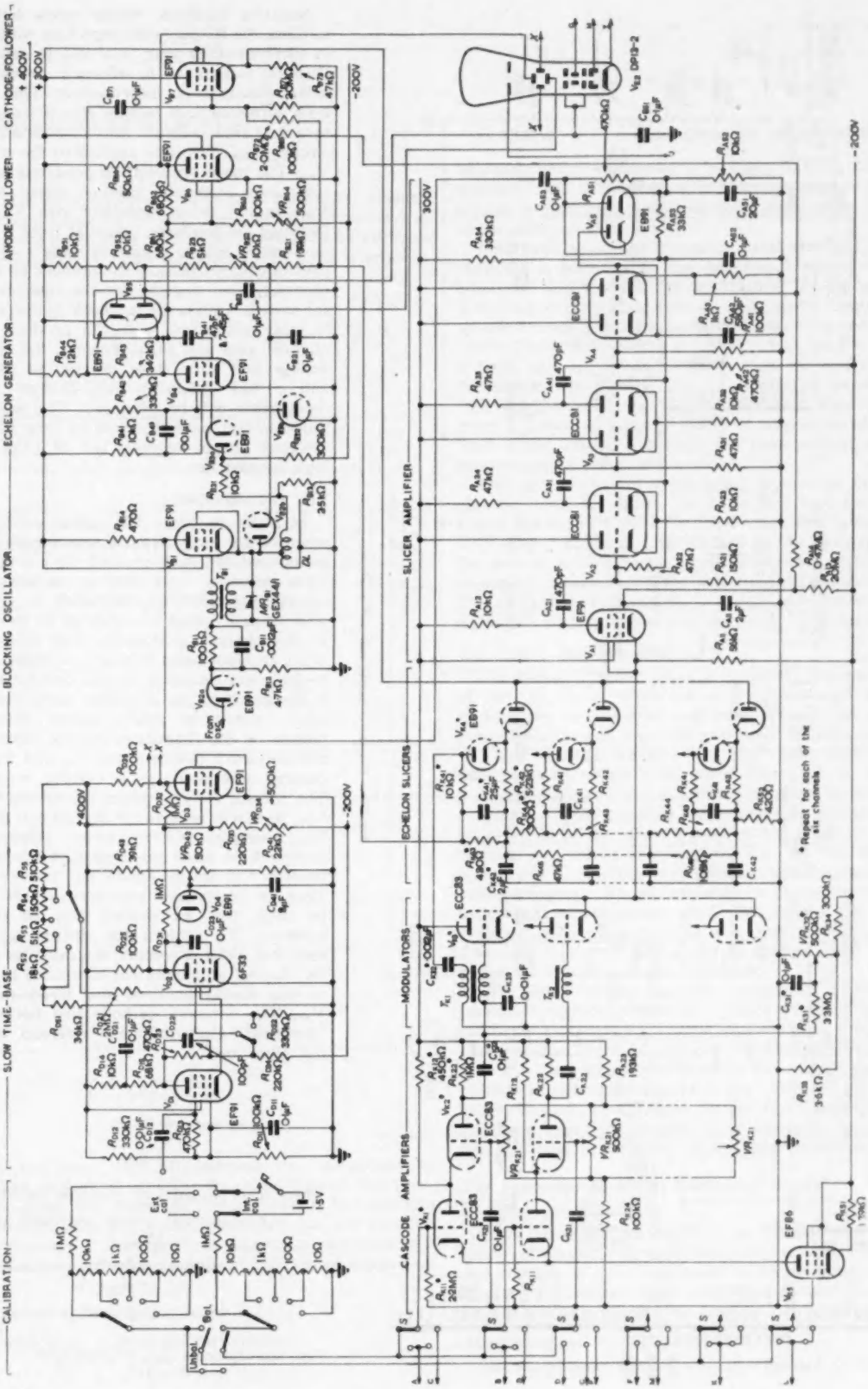


Fig. 2(a) The oscilloscope circuit *(continued on page 68)*

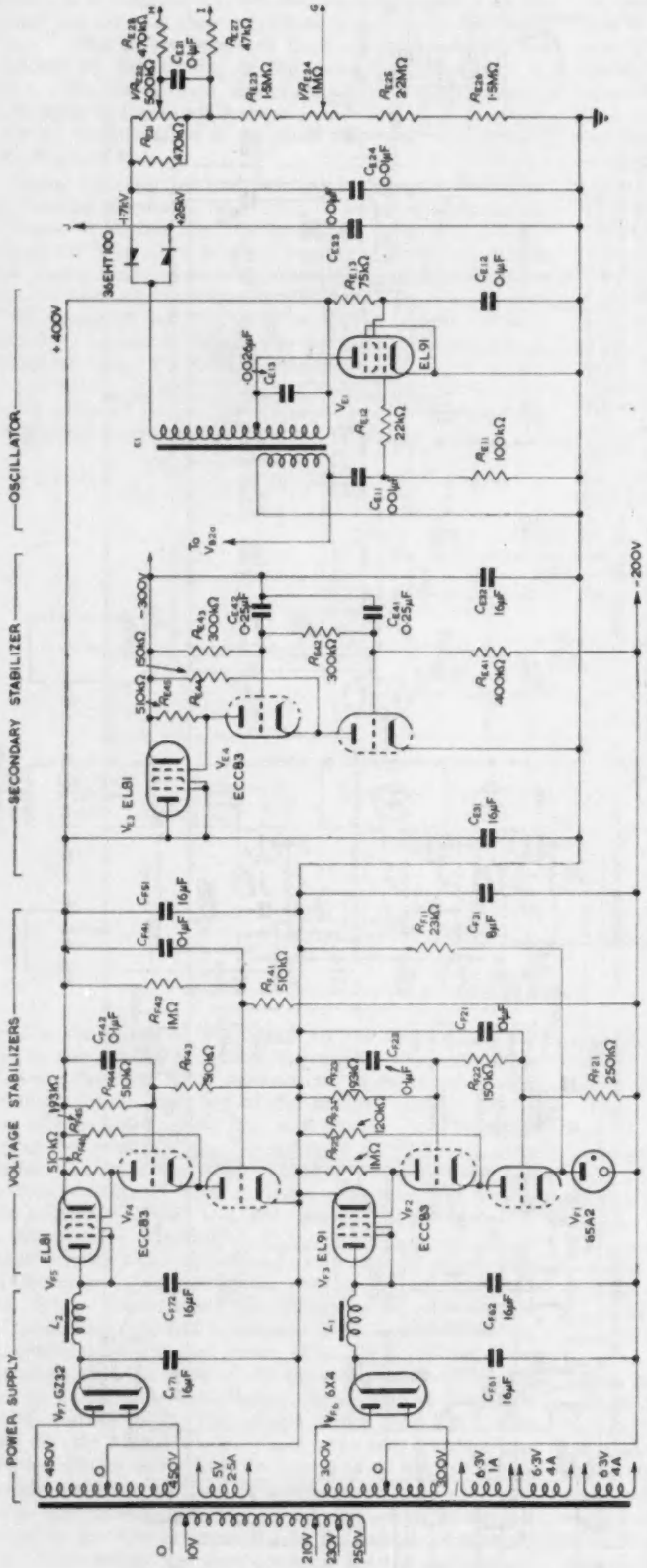


Fig. 2(b). The power supply unit and oscillator

Negative feedback which serves both to stabilize the output with respect to variations in slicer-amplifier gain, and also to refer the channel outputs to a reference 'weighted' mean potential is incorporated. The pulse train across cathode resistor R_{A43} is integrated by a long time-constant resistance-capacitance circuit (R_{A14}, C_{A11}) and applied to the grid of V_{A1}. The mean potential so produced is thus subtracted from the channel signal across R_{K31}, in the pulse modulator pair V_{K3}-V_{A1}. Deriving the feedback potential from a common output system instead of using a separate control channel reduces the number of valves necessary, but complicates the operation of the system. Unless the feedback time-constant is large compared with the product of a channel gain and pulse interval, the control voltage will vary from channel to channel and a high frequency inter-channel cross-modulation will be produced. The feedback time-constant must therefore be long and the resultant output becomes out of balance at high frequencies.

The pre-amplifier

In order to make the system sufficiently sensitive for e.e.g. work a pre-amplifier was introduced for each channel. It was known from previous work that a random noise voltage equivalent approximately to 100μsec peak-to-peak could be expected at the input of the channel modulators. For e.e.g. purposes an input noise level of 1 to 3μsec peak-to-peak was necessary. It was decided to use a pre-amplifier, the amplified input noise of which would be much greater than the 100μsec at the channel modulator input. For this purpose a double triode V_{K1} and V_{K2} per channel was used, as a cascode amplifier. The resistor R_{K12} by-passes the second triode V_{K2}, so that 0·5mA anode current can flow in V_{K1}, giving an effective mutual conductance of 0·6mA/V, while only approximately 0·1mA flows in V_{K2} and its anode load resistor R_{K22}. Thus an anode load resistance of 1MΩ can be used, and an overall gain of 600 is achieved. To achieve the desired unipolar electrical mean properties, the cathodes of the six channel amplifiers are connected together as the anode load of the EF86 pentode V_{K5}. The common cathode line becomes a 'weighted' electrical mean reference potential given by

$$\delta v_k = \frac{r_a \sum_1^n g_m \delta v_{g1}}{1 + r_a \sum_1^n g_m}$$

where v_k = potential of common cathodes

r_a = internal anode resistance of V_{K5} $\simeq$ 1MΩ.

g_m = mutual conductance of each triode $V_{K1} \simeq 0{\cdot}6$mA/V.

v_{g1} = input grid-ground potential.

For six channels $\sum_1^n g_m \simeq 3{\cdot}6$mA/V

Therefore $r_a \sum_1^n g_m \simeq 3\,600$

Therefore one can put this as $\delta v_k = \dfrac{\sum_1^n g_m \, \delta v_{gi}}{\sum_1^n g_m}$

which is a weighted mean of the input potentials. A preset adjustment VR_{K21} of the grid potential of the triodes V_{K2}, enables one to equalize their anode currents and thus those of the triodes V_{K1}. Since for triodes V_{K1}, g_m/i_a is approxi-

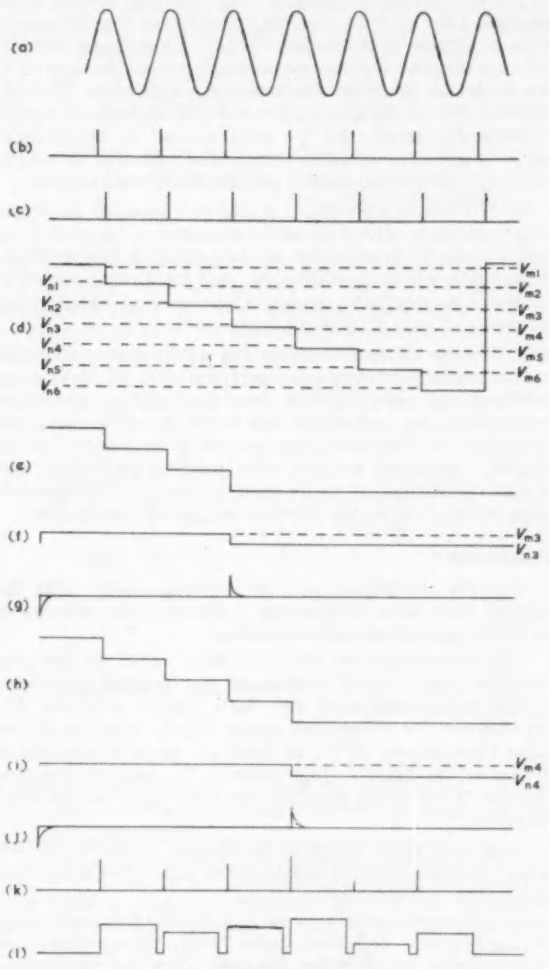


Fig. 3. Waveform diagram

mately the same, this arrangement was introduced to provide a method of equating the channel gains. For practical purposes the important consideration is the rejection of unwanted hum and muscle potentials that are common to all channels. If the input grid signals are expressed as a common signal δv_g plus an individual channel signal δv_{gi}, then

$$\delta v_{gi} = \delta v_g + \delta v_{gi}$$

The output from a given channel anode is

$$R_a g_m \, (\delta v_{gi} - \delta v_k)$$

$$= R_a g_m \left(\frac{\delta v_g}{1 + r_a \sum_1^n g_m} + \delta v_{gi} - \frac{\sum_1^n g_m \, \delta v_{gi}}{\sum_1^n g_m} \right)$$

The factor $(1 + r_a \sum_1^n g_m)$ gives the out of balance rejection ratio which was shown to be approximately 3 600. This rejection ratio is obtained in practice, so long as no phase change or frequency distortion takes place before the grids of the input amplifiers.

The restriction of the frequency band necessary for e.e.g. purposes is achieved in the coupling between the input amplifiers and the channel modulators. In the prototype switching of the time-constant and upper frequency response has not been incorporated. A fixed time-constant of: $C_{K22} = 0{\cdot}1\mu F$, $R_{K31} + R_{K22} = 3{\cdot}3 + 1{\cdot}0M\Omega$, i.e. $T = 0{\cdot}25$sec. is used, and the upper frequency response determined by the anode load resistor $R_{K22} = 1{\cdot}0M\Omega$ in parallel with $R_{K31} = 3{\cdot}3M\Omega$ and the by-pass capacitor $C_{K23} = 0{\cdot}01\mu F$, gives a cut-off frequency (3dB) of approximately 20c/s. Such a low cut-off frequency was incorporated as a precaution against 50c/s pick-up.

The only limitation experienced in the use of the six cascode input amplifiers, is the rather high noise level. Using unselected 12AX7 (ECC83) which had been given a 300h ageing period during which 6·3V d.c. was applied to the heaters, a fundamental input noise level of $5\mu V$ peak-to-peak is obtained with the above input bandwidth 0·5 to 20c/s. This is obtained using a 12V d.c. heater supply, stabilized only by the use of a constant voltage transformer.

The Ancillary Circuits

The system of seven spots in a vertical line on the face of the c.r.t., six of which are vertically deflected, is moved horizontally by the slow time-base. A balanced deflexion potential is derived from the anodes of a Miller-transitron V_{D2} and an anode-follower V_{D3}. The speed of the trace is switchable to values 3, 10, 30 or 100cm/sec by returning the grid resistor of V_{D1} to various tappings of the resistor chain R_{D51-55}. The coupling from the screen grid to the suppressor grid of the Miller transitron V_{D2} is effected via the cathode and anode of a pentode V_{D1}. By this means the system can be maintained indefinitely with the anode of the Miller-transitron V_{D2} cut off, without exceeding the power dissipation of the screen grid. The circuit can thus be switched from a free-running to a single stroke condition. The suppressor grid of V_{D1} can be used to inject pulses to trigger or synchronize the time-base.

The power supply for the equipment consists of a stabilized negative supply of -200V which is used as a reference potential to control a stabilized 400V supply and a second doubly stabilized $+300$V supply. A stabilizer type 85A2 is used as a reference for the -200V supply, and cascode amplifiers are used in all the stabilizers. The $+300$V supply is used only for those circuits which require a highly stabilized supply to minimize inter-channel cross-modulation and random variations of the pulse amplitude.

The Performance of the Laboratory Model

Linearity of Response

Since the signals are displayed on the face of a c.r.t. and no power amplifier stages or pen recorders are involved, the major source of non-linearity would be the pulse amplitude detector. A Lissajous figure method of measurement on the face of the c.r.t. showed no appreciable non-linearity.

Amplification

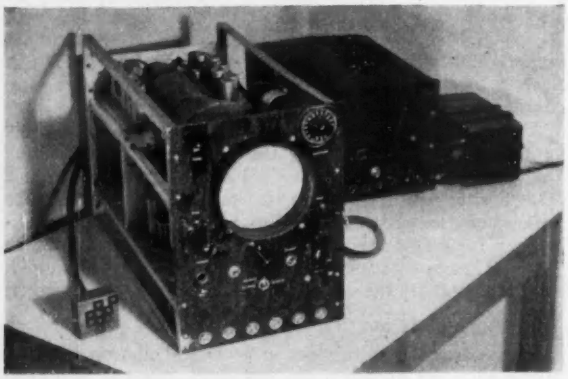
No overall gain control was incorporated in the model.

The variation of individual channel gain, achievable by adjustment of the cascode 2nd grid potential proved to be not sufficient to compensate for the variations of channel modulators. A more satisfactory method of adjustment of the modulator transconductance must be developed for a future model. A signal of 50μV applied to each channel produced a spot deflexion of approximately 10mm. For each channel the maximum working deflexion is 1·3mm, the spot size is approximately 0·3mm, thus a ratio:

$$\frac{\text{Maximum working deflexion}}{\text{Minimum visible deflexion}} = 40 \text{ is obtained}$$

FREQUENCY RESPONSE

The limitations of the design are such that with an echelon repetition frequency of 1kc/s, an upper response frequency of 300c/s is attainable. The lower response frequency is determined solely by the inter-stage capacitor resistor coupling between the cascode anodes and the



The complete instrument

channel modulators. This model had a fixed upper response frequency of 25c/s (3dB) and a time-constant of 0·4sec for e.e.g. use.

BASIC IRREGULARITY

With the inputs connected to ground the channels have a 'noise' variation of approximately 3μV.

DISCRIMINATION

With all the channel inputs connected together, a potential applied between the inputs and ground produces a deflexion no greater than 0·1 per cent of that produced by the same potential applied between one electrode and all the rest.

CALIBRATION

A small switched calibrator was included which gives balanced or unbalanced inputs of 7·5μV, 75μV, 750μV, 7·5mV.

WRITING SPEEDS

The time-base could be used in either a self-running or single-stroke condition at speeds of 1cm/sec, 3cm/sec, or 10cm/sec.

PHYSICAL DIMENSIONS

The instrument consisted of a display unit 18in by 12 in by 9in of 20lb weight and a power supply unit 12in by 9in by 8in of 22½lb weight. The total power consumption was less than 150W.

The Use of the Instrument for E.E.G. Diagnosis

Since no permanent record of the e.e.g. is taken, this instrument cannot be used as an ultimate reference for diagnostic purposes. However, it can play an active part, in places where the cost of a large e.e.g. machine is prohibitive, in selecting patients for reference to the distant e.e.g. departments.

A clinical survey of the validity of this instrument for diagnostic purposes, is still in progress. No adequate conclusions can yet be drawn, but the following observations appear.

(1) The appearance of the traces is indistinguishable from an ordinary e.e.g. record, but the short time available for observing any section of the record, make greater demands on the intelligence and quickness of the operator. It is important that the operator should know what to look for.

(2) Without any additional time marking system, it is possible, after a little practice, to estimate the frequency of an oscillation in the range of 1 to 15c/s to approximately 1c/s by simple observations and estimations by eye of a few cycles. A time marking pulse was applied to the c.r.t. blacking out all the traces for a few milliseconds at a controllable frequency, this by itself proved to be of little value. It would be of more value if the repetitive time-base were synchronized to several periods of the time marker.

(3) The assumption that it would be impossible to detect phase reversals proved invalid, although it is impossible to detect them by observation of the yellow afterglow trace. By watching the spots themselves, and the direction of their vertical movement, it is comparatively easy to detect phase reversals, at least of adjacent traces.

(4) The use of unipolar recording, with only six channels is not justified. In practice, the distribution of focal e.e.g. gradients are such that the steep potential gradients are localized in the region of one electrode only. In these circumstances, the averaging potentials that occur in the unipolar recording method, only produce confusion, and bipolar recordings are much more satisfactory for approximate localization by the observations of voltage maxima.

Conclusion

Since the completion of this instrument and while the clinical trials were progressing, work has been proceeding on other approaches and techniques.

The replacement of the thermionic valves in the preamplifier and channel modulators by junction transistors would reduce the need for both highly stabilized h.t. supplies and for a stabilized heater supply. Junction diodes have been shown to be at least as good as thermionic diodes in the channel slicer circuits. The new r.f. junction transistors are being tried for the first stages of the slicer amplifier.

As an alternative approach to the pulse multiplex system, a ring stepping register system using ferrite saturable magnetic cores is being tried.

An alternative display system is being developed using electromagnetic deflexion radar p.p.i. tubes which can economically be of larger diameter than the electrostatic deflexion c.r. tubes. A linear current sawtooth, synchronized with the echelon waveform, deflects the c.r.t. spot in a vertical line. The output waveform from the pulse amplitude detector is transformed into a train of short pulses time modulated by the amplitude modulation of the previous output pulses. These short pulses are applied to the grid of the c.r.t. producing spots whose vertical position reproduces the vertical arrangement of the spots of the electrostatically deflected tube. A slow current sawtooth deflects the whole system horizontally to produce the same patterns as before. A recorder, which uses this principle to produce a permanent record on Teledeltos paper is showing considerable promise.

A New Bistable Element Suitable for Use in Digital Computers

(Part 1)

By C. D. Florida*, A.M.I.E.E.

The article describes the development of a trigger circuit which uses both pnp and npn types of transistor. The circuit has fast (0·2μsec) switch-on and switch-off times but is characterized primarily by its current handling capacity and hence by its ability to drive several other similar circuits. The transient response of this circuit to a voltage ramp input at either the turn-on or the turn-off terminals is dealt with in two mathematical appendices. The method is to divide each operation into a number of discrete stages, each of which is terminated by a significant change in the circuit configuration (e.g. a diode current falling to zero, thereby isolating the diode from the circuit). The initial conditions for any stage are derived from the equations for the preceding stage, and are inserted into the equations at the same time that the force functions are replaced by their Laplace transforms. The inverse Laplace transform then gives the required response for that stage as a function of time.

Results of the mathematical treatment are plotted, assuming certain circuit values and also assuming that the trigger circuit under analysis is driving five other similar circuits. Experimental results are also plotted and it is seen that the agreement is good.

A TRANSISTOR operated digital computer is being built at the laboratories of the Defence Research Board in Canada. For the purpose of the present article it is sufficient to state that this computer uses trigger circuits inter-connected by passive gates. With this type of gate it is desirable that a trigger circuit should combine fast switching speeds, high current handling capacity and a low output impedance. Table 1 shows a specification for

Fig. 1. The symbols used

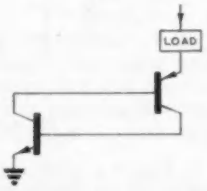


Fig. 2. Basis of fast switching circuit

a trigger circuit which will meet the requirements of this computer, and the development of such a circuit is described in this article.

The circuit uses both pnp and npn types of transistor and it is consequently necessary to distinguish between these types in diagrams. Although they are not considered ideal, the symbols specified by B.S.I. are used and these are shown in Fig. 1.

TABLE 1
Specification

Switching time	< 0·2μsec
Output fall time when driving 5 similar stages	< 0·2μsec
Output rise time when driving 5 similar stages	< 0·5μsec
Output load current	> 30mA
Output impedance	< 20Ω
Resolving time	< 1·5μsec

* *Defense Research Telecommunication Establishment, Canada.*

Development of the Circuit

If two transistors, one an npn, the other a pnp are joined together as shown in Fig. 2, there exists the basis of a fast switching circuit as the regeneration is the highest possible for any way of connecting together two transistors. This rudimentary circuit has stability in the on state and the ability to handle high currents, limited only by the wattage dissipation of the transistors.

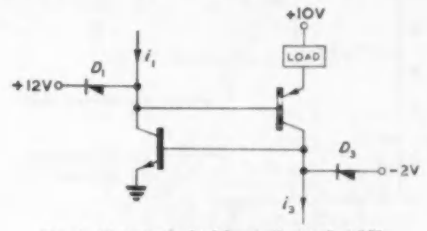


Fig. 3. Method of obtaining 'off state' stability

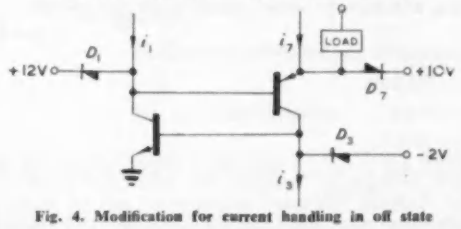


Fig. 4. Modification for current handling in off state

Stability in the off state can be gained by the addition of two current sources and two diodes, one to each base, as shown in Fig. 3. A reverse bias of 2V is applied to each transistor when in the off state, and it is easy to ensure that the current sources are large enough to take care of any possible value of collector leakage current.

The circuit in this form has stability in both the on and the off states and can handle high currents when in the on state. In the off state, however, it cannot handle any current. This may be corrected by the addition of another current source and diode as shown in Fig. 4. Here a current i_7 flows into the diode D_7. Any current up to this value may be withdrawn from the structure without change of potential, while the current flowing into the structure is limited only by considerations of diode wattage.

Switching the circuit from off to on may be accomplished by any means which injects current into the regenerative loop. One effective method is shown in Fig. 5. Diode D_4 is inserted and a negative-going voltage waveform is applied to the capacitor C.

Switching Speed

The development of the trigger circuit has thus reached the point where there are stable off and on states, high current handling capacity in both states, low output impedance, and a means for switching from off to on. The switching speed is analysed in fair detail in Appendix A. There, it is shown that the switching process can be divided into several discrete stages, and an equation is given for each stage from which the time taken for that stage can be derived. The results of this Appendix have been applied

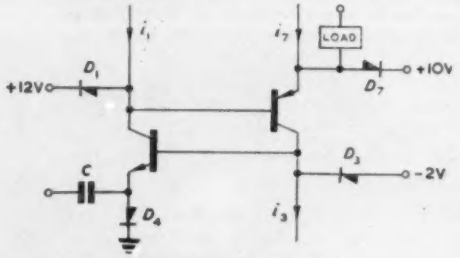


Fig. 5. Method of switching

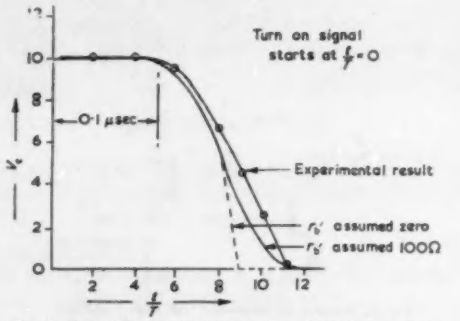


Fig. 6. Potential at output terminal against time-constants

to a circuit with the following parameters:

$i_1 = 0{\cdot}25$mA

$i_3 = 3$mA

$i_7 = 10$mA

Transistor α cut-off frequency $= 8$Mc/s ($T = (1/2\pi f_c) = 2 \times 10^{-8}$sec)

Transistor base/collector capacitance 10pF ($k = 0{\cdot}2$)

Input capacitor = 100pF

Input voltage fall = 10V in 0·2μsec ($a = 5{\cdot}10^7$V/sec)

Output capacitor = 500pF ($n = 5$)

The value chosen for the output capacitor is equivalent to a loading of five trigger circuits identical with the one being discussed.

Fig. 6 shows computed and experimental results for the potential at the output terminal V_c, plotted against transistor time-constants. It will be seen that the turn-on cycle can be broken down into a delay of about 0·1μsec and a fall time of about the same duration. For the early stages in the switching process, where the transistor currents are low, the agreement between the computed and experimental values is good, but during the rapid portion of the fall the agreement is only fair. This is not unexpected since the analysis is based on the assumption that transistor parameters are invariant with voltage and current, and a fall at the rate of that shown by a dashed line corresponds with transistor currents of up to 300mA. Even so, it is thought that the analysis will permit overall times to be computed with an accuracy not worse than ±10 per cent if a non-zero value is assumed for base spreading resistance during the times of rapid voltage change.

Further Development

In the circuit of Fig. 5 the fall of the output electrode continues until both transistors saturate. This would cause the circuit to be difficult to turn off but can be avoided by the use of two catching diodes, as in Fig. 7, which ensures a base-collector separation of 3V in the on state.

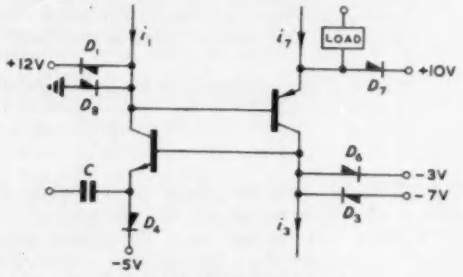


Fig. 7. Addition of catching diodes

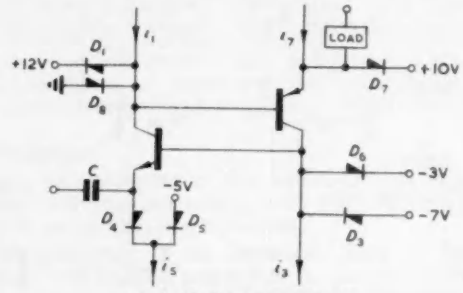


Fig. 8. Modification of Fig. 7

In Fig. 7 a path exists for virtually unlimited current to flow in the npn transistor (via D_8 and D_4). This can be prevented by feeding this transistor with a constant current i_5 of, say, 5mA as in Fig. 8. Any loss of fall time resulting from the restriction on current can be compensated by attaching a capacitor at the junction of D_4 and D_5 to provide a momentary source of high current.

When switching on has been completed, nearly 5mA is available, either to D_8 or to the base of the pnp transistor, which acts as an emitter-follower. If this transistor has a current gain of 20 then up to 100mA can be extracted from the load for a change in potential of only a few tenths of a volt—an output impedance of around 10Ω.

The circuit in this form has fast switching speed, high current-handling capacity and low impedance in both the on and the off states, and the ability to drive at least five similar circuits. It is clamped in the off state at +10V and at ground potential in the on state. It remains to turn it off.

Turn off can be effected in many ways, but in order to equalize turn-on and turn-off sensitivities, and to make turn-off sensibly independent of load, it is preferable to use an extra transistor connected as in Fig. 9.

This transistor normally has 1V of reverse bias. Appli-

cation of a negative-going turn-off signal will cause base current to flow, thereby inducing an amplified current in the collector circuit. This current as it increases, first turns off D_8 and then feeds the output transistor with reverse base current so that its emitter current is eventually reduced to zero. The output transistor will thus turn off, and the surplus current from the turn-off transistor will charge up the base-collector capacitances so that the potential at the pnp base rises until D_1 switches on.

When D_1 switches on further positive excursion is stopped. This prevents the turn-off transistor from saturating and also causes the current previously flowing in the base-collector capacitances to cease abruptly. Cessation of this current causes D_6 to cease conduction so that the base of the npn transistor is free to fall in potential, so switching off that transistor.

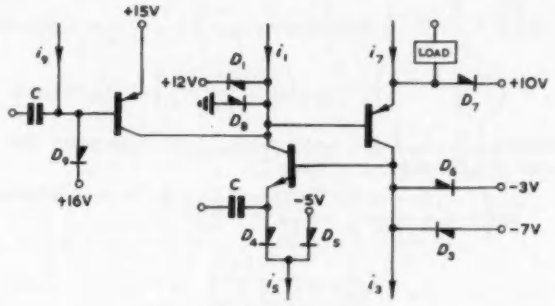


Fig. 9. Method of 'turning-off'

Appendix A

Turn On

Fig. A.1 is the same as Fig. 5 of the article, with the addition of collector-base and emitter-base capacitances. If a negative-going voltage ramp is applied to the capacitor C, as shown, the turn-on cycle has a number of stages, as follows:

(1) The d.c. starting potential at the emitter of X_1 is indeterminate as it is governed by the reverse resistances of D_3, X_1 base-emitter diode, and D_4. No current can flow in X_1 until this potential has been reduced to that on D_3 (-2V). Stage 1 is the time taken for this to occur.

(2) During stage 2 emitter current flows in X_1, whose collector current starts to rise at a rate depending on the α cut-off of the transistor. When this collector current reaches a value i_1, D_1 cuts off.

(3) In stage 3 X_1 collector current continues to rise, the surplus over i_1 being drawn from C_e (pnp) and $2C_c$. This stage is terminated when X_2 commences to draw current.

(4) Once X_2 draws current its emitter and base are held at $+10$V. X_2 collector current builds up until stage 4 is ended by D_3 switching off.

(5) The base of X_1 is now free to rise from -2V to ground potential. The time taken for this to occur comprises stage 5. During this stage D_7 may cease conduction owing to X_2 emitter current exceeding i_7. If this happens, stage 5 is terminated at this point.

(6) If stage 5 ends because of the release of D_7, stage 6 covers the remaining time before the potential of X_1 base reaches ground potential.

(7) During stage 7 the output electrode falls in potential to ground level.

These stages are all calculable and results can be computed using measured parameter values. However, two stages contain parameters which may change with time or from circuit to circuit, or which require excessive measurement time. These stages are (1) because of the dependence of starting potential on reverse resistances and also because of the difficulty of predicting from measurements the effective value of C_e as the transistor base-emitter potential

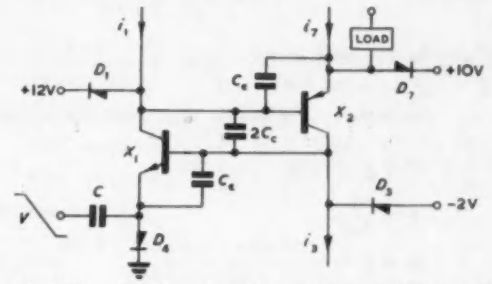


Fig. A1. Addition of collector-base and emitter-base capacitances to Fig. 5

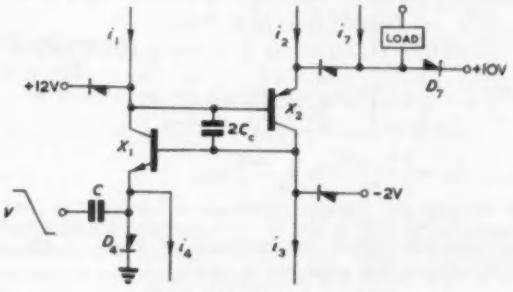


Fig. A2. Modification of Fig. A2

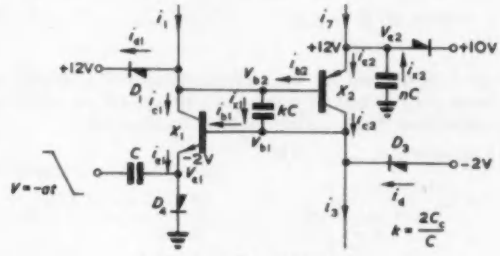


Fig. A3. Circuit for analysis

nears zero, and (3) again because of C_e. These difficulties can be overcome, both for purposes of analysis and also in practice by the provision of 'wetting' currents to both transistors. C_e then becomes merged with the diffusion capacitance which is represented in the operational form for current gain, while the emitter of X_1 is held at -2V by diode action when the circuit is in the off state. Fig. A.2 shows the modified circuit. The only necessary tolerance conditions are

$$i_4 < i_1 - 2I_{co}$$

$$i_2 < i_3 - 2I_{co}$$

In the analysis it will be assumed that i_2 and i_4 are so small that they do not influence the circuit in any ways other than those just described.

It will be assumed that the load consists of a number, n, of stages in parallel, each similar to the one being analysed. To a close approximation this load is given by n capacitors each of value C.

As X_1 and X_2 bases are nearly always fed from high

impedance sources, very little error will occur if it is assumed that the base spreading resistance is zero.

The circuit for analysis now appears as in Fig. A.3. The presence of transistor wetting currents is implied by writing the emitter potentials near the emitters. In the analysis the stage numbers will be altered from those previously described, because the former stage 1 has now been deleted.

Stage 1

We have $i_{e1} = -pCV$

$$V = -at$$

$$i_{c1} = \alpha i_{e1}$$

$$\alpha = \frac{\alpha_o/T}{p + (1/T)}$$

$$T = \frac{1}{2\pi f_{\alpha o}}$$

$$i_{d1} = i_1 - i_{e1}$$

Combining these equations,

$$i_{d1}(p + (1/T)) - i_1(p + (1/T)) + p(\alpha_o/T)\,aCT = 0$$

Initially $i_{d1} = i_1$, $at = 0$

$$\therefore \overline{i_{d1}}(p + (1/T)) - \overline{i_1}(p + (1/T)) + p(\alpha_o/T)\,\overline{aCt} = i_1 - i_1 = 0$$

$$\overline{i_1} = (i_1/p),\ \overline{aCt} = (aC/p^2)$$

$$\therefore \overline{i_{d1}}\,p(p + (1/T)) - i_1(p + (1/T)) + (\alpha_o/T)\,aC = 0$$

$$\therefore \overline{i_{d1}} = \frac{i_1 - \alpha_o aC}{p} + \frac{\alpha_o aC}{p + (1/T)}$$

$$\therefore i_{d1} = i_1 - \alpha_o aC(1 - e^{-t/T}) \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

This equation defines the duration of stage 1. Also of interest during this stage are i_{c1} and i_{d3}.

$$i_{c1} = i_1 - i_{d1} = \alpha_o aC(1 - e^{-t/T}) \quad \ldots\ldots\ldots \quad (2)$$

$$i_{d3} = i_3 + i_{b1} = i_3 + i_{e1} - i_{c1} = i_3 + aC - \alpha_o aC(1 - e^{-t/T})$$

$$= i_3 + aC[1 - \alpha_o(1 - e^{-t/T})] \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Stage 2

Stage 2 is defined by the time taken for V_{b2} to fall by 2V (from +12 at end of stage 1 as D_1 cuts off to +10V as X_2 emitter-base diode action inhibits further fall).

We have $V_{b2} = -i_{x1}/pkC$

$$i_{x1} = i_{c1} - i_1$$

$$i_{c1} = \alpha i_{e1} = \alpha aC$$

$$\alpha = \frac{\alpha_o/T}{p + (1/T)}$$

Combining,

$$V_{b2}\,p(p + (1/T)) + (\alpha_o aC/kCT) - (i_1/kC)(p + (1/T)) = 0$$

Initially $V_{b2} = 0$, $(dV_{b2}/dt) = 0$,

$$\therefore \overline{V_{b2}}\,p(p + (1/T)) + (\alpha_o\overline{aC}/kCT) - \overline{(i_1/kC)}\,(p + (1/T)) = -(i_1/kC)$$

$$\overline{a} = (a/p),\ \overline{i_1} = (i_1/p)$$

$$\therefore \overline{V_{b2}}\,p^2(p + (1/T)) + \alpha_o aC/kCT - (i_1/kCT) = 0$$

$$\therefore \overline{V_{b2}} = (T/kC)(i_1 - \alpha_o aC)\,[(1/Tp^2) - (1/p) + (1/p) + (1/T))]$$

$$\therefore V_{b2} = (T/kC)(i_1 - \alpha_o aC)\,[(t/T) - 1 + e^{-t/T}] \quad \ldots. \quad (4)$$

This is the governing equation for this stage, but one is also interested in i_{c1} and i_{d3}

$$i_{c1} = i_1 - kC(dV_{b2}/dt) = \alpha_o aC - [\alpha_o aC - i_1]\,e^{-t/T} \quad .. \quad (5)$$

$$i_{d3} = i_3 - kC(dV_{b2}/dt) + aC - i_{c1}$$

$$= i_3 + aC - i_1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

Stage 3

At the end of stage 2, X_2 commences to draw current. This current will build up until D_3 cuts off. This time interval is termed stage 3.

We have $i_{d3} = i_3 + i_{b1} - i_{c2}$

$$i_{b1} = i_{e1} - i_{c1}$$

$$i_{c1} = \alpha i_{e1}$$

$$i_{c2} = \frac{\alpha}{1 - \alpha} i_{b2} = \frac{\alpha}{1 - \alpha}(i_{c1} - i_1)$$

$$= \frac{\alpha^2}{1 - \alpha} i_{e1} - \frac{\alpha}{1 - \alpha} i_1$$

$$\therefore i_{d3} = i_3 + i_{e1}\frac{1 - 2\alpha}{1 - \alpha} + \frac{\alpha i_1}{1 - \alpha}$$

Writing $\alpha = \dfrac{\alpha_o/T}{p + (1/T)}$ and re-arranging,

$$i_{d3}\left(p + \frac{1 - \alpha_o}{T}\right) - i_3\left(p + \frac{1 - \alpha_o}{T}\right) - i_{e1}\left(p + \frac{1 - 2\alpha_o}{T}\right) - i_1(\alpha_o/T) = 0.$$

Initially $i_{d3} = i_{e1} + i_3 - i_{c1}(t_2)$ where $i_{c1}(t_2)$ represents the value of i_{c1} at the end of stage 2,

$$\therefore \overline{i_{d3}}\left(p + \frac{1 - \alpha_o}{T}\right) - \overline{i_3}\left(p + \frac{1 - \alpha_o}{T}\right) - \overline{i_{e1}}\left(p + \frac{1 - 2\alpha_o}{T}\right) - \overline{i_1}(\alpha_o/T) = -i_{c1}(t_2)$$

$$\overline{i_3} = (i_3/p),\ \overline{i_{e1}} = (aC/p),\ \overline{i_1} = (i_1/p)$$

$$\therefore \overline{i_{d3}}\,p\left(p + \frac{1 - \alpha_o}{T}\right) - i_3\left(p + \frac{1 - \alpha_o}{T}\right) - aC\left(p + \frac{1 - 2\alpha_o}{T}\right) - i_1(\alpha_o/T) = -pi_{c1}(t_2)$$

$$\text{or } \overline{i_{d3}} = \frac{i_3 + aC\dfrac{1 - 2\alpha_o}{1 - \alpha_o} + i_1\dfrac{\alpha_o}{1 - \alpha_o}}{p} + \frac{(aC - i_1)\dfrac{\alpha_o}{1 - \alpha_o} - i_{c1}(t_2)}{p + [(1 - \alpha_o)/T]}$$

$$\therefore i_{d3} = i_3 + aC\frac{1 - 2\alpha_o}{1 - \alpha_o} + i_1\frac{\alpha_o}{1 - \alpha_o} + [(aC - i_1)\frac{\alpha_o}{1 - \alpha_o} - i_{c1}(t_2)]\,\exp[-\frac{1 - \alpha_o}{T}t] \quad .. \quad (7)$$

By analogy with equation (5), i_{c1} during stage 3 is given by

$$i_{c1} = \alpha_o aC - [\alpha_o aC - i_{c1}(t_2)]\,e^{-t/T} \quad \ldots\ldots\ldots \quad (8)$$

Also,

$$i_{e2} = i_{e1} + i_3 - i_1 - i_{d3}$$

$$= aC\frac{\alpha_o}{1 - \alpha_o} - i_1$$

$$- [(aC - i_1)\frac{\alpha_o}{1 - \alpha_o} - i_{c1}(t_2)]\,\exp[-\frac{1 - \alpha_o}{T}t] \quad \ldots. \quad (9)$$

and $i_{c2} = i_3 + i_{b1} - i_{d3} = i_3 + i_{e1} - i_{c1} - i_{d3}$

$$= \frac{\alpha_o}{1 - \alpha_o}(\alpha_o aC - i_1) + [\alpha_o aC - i_{c1}(t_2)]\,e^{-t/T} -$$

$$[(aC - i_1)\frac{\alpha_o}{1 - \alpha_o} - i_{c1}(t_2)]\,\exp[-\frac{1 - \alpha_o}{T}t] \ldots. \quad (10)$$

Stage 4

When the current in D_3 has been reduced to zero this diode cuts off. There are then no diodes in circuit except D_7. V_{b1} is free to rise in potential and the total current through the structure can increase rapidly as heavy re-

generation is present. With values of supply currents as normally used the increase in structure current causes D_7 to switch off ($i_{e2}=i_7$) before V_{b1} rises to zero volts causing D_4 to conduct. Stage 4 therefore comprises the time taken for i_{e2} to increase from its value at the end of stage 3 (which must be $aC + i_3 - i_1$) to i_7.

We have $i_{e2} = i_{e1} + i_3 - i_1$

$$i_{e1} = pC(V_{b1} - V)$$

$$V_{b1} = (i_{x1}/pkC)$$

$$i_{x1} = i_{e2} - i_3 - i_{b1}$$

$$i_{e2} = \alpha i_{e2}$$

$$i_{b1} = (1 - \alpha)i_{e1}, \text{ from which}$$

$$i_{e2} = \frac{i_3(k - \alpha) - VpkC - i_1(k + 1 - \alpha)}{k + 1 - \alpha}$$

Writing $\alpha = \dfrac{\alpha_0/T}{p + (1/T)}$, and re-arranging,

$$i_{e2} = \left(p + \frac{k + 1 - 2\alpha_0}{(k + 1)T}\right) - \frac{i_3}{k + 1}\left(p + \frac{k - \alpha_0}{T}\right) + \left(\frac{VpkC}{k + 1}(p+(1/T)\right)+i_1\left(p + \frac{k+1-\alpha_0}{(k + 1)T}\right) = 0$$

Initially $i_{e2} = aC+i_3-i_1$, $V = 0$, $dV/dt = -a$,

$$\therefore \overline{i_{e2}}\left(p + \frac{k + 1 - 2\alpha_0}{(k + 1)T}\right) - \frac{\overline{i_3}}{k + 1}\left(p + \frac{k - \alpha_0}{T}\right) + \left(\frac{\overline{V}pkC}{k + 1}(p+(1/T)\right)+\overline{i_1}\left(p + \frac{k+1-\alpha_0}{(k+1)T}\right) = \frac{aC+ki_3}{k + 1}$$

$\overline{i_3} = (i_3/p)$, $\overline{V} = (a/p^2)$, $\overline{i_1} = (i_1/p)$

$$\therefore \overline{i_{e2}}\left(p + \frac{k+1-2\alpha_0}{(k+1)T}\right) - \frac{i_3}{k + 1}\left(p + \frac{k - \alpha_0}{T}\right) - \left(\frac{akC}{k+1}(p+(1/T)\right)+i_1\left(p + \frac{k+1-\alpha_0}{(k+1)T}\right) = p\,\frac{aC+ki_3}{k + 1}$$

$$\therefore \overline{i_{e2}} = \frac{kaC + i_3(k - \alpha_0) - i_1(k + 1 - \alpha_0)}{p(k + 1 - 2\alpha_0)} + \frac{aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1}{(k+1-2\alpha_0)\left(p + \dfrac{k+1-2\alpha_0}{(k+1)T}\right)}$$

$$\therefore i_{e2} = \frac{kaC + i_3(k - \alpha_0) - i_1(k + 1 - \alpha_0)}{k+1-2\alpha_0} + \frac{aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1}{k+1-2\alpha_0} \exp\left[-\frac{k + 1 - 2\alpha_0}{k + 1} \cdot t/T\right] \quad \ldots\ldots\ldots (11)$$

As $\alpha_0 \to 1$ this expression simplifies to

$$i_{e2} = \frac{\alpha C - i_1}{1 - k}\left(\exp\left[\frac{1 - k}{1 + k}\,t/T\right] - k\right) + i_3 \quad \ldots\ldots (12)$$

which reveals the positive exponential in the current build-up to be expected in a trigger circuit.

During the next stage we shall need as starting conditions both the potential and the rate of change of potential of V_{b1} at the end of the present stage.

From $i_{e2} = i_{e1} + i_3 - i_1$

$i_{e1} = pC(V_{b1} - V)$, and equation (11)

we get

$$V_{b1} = (1/C)\int_0^t \frac{aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1}{k+1-2\alpha_0}\left(\exp\left[-\frac{k+1-2\alpha_0}{k+1}t/T\right]-1\right)$$

$$= \frac{aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1}{C(k+1-2\alpha_0)}\left[-\frac{(k+1)T}{k+1-2\alpha_0}\exp\left(-\frac{k+1-2\alpha_0}{k+1}t/T\right)-t\right]_0^t$$

$$= \frac{T[aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1]}{C(k+1-2\alpha_0)}\left[\frac{k+1}{k+1-2\alpha_0}\left(1-\exp\left[-\frac{k+1-2\alpha_0}{k+1}-(t/T)\right]\right)t/T\right] \quad (13)$$

As $\alpha_0 \to 1$ this expression simplifies to

$$V_{b1} \to \frac{T(aC - i_1)}{C(1-k)}\left[\frac{1+k}{1-k}\left(\exp\left[-\frac{1-k}{1+k}t/T\right]-1\right)-(t/T)\right] \quad (14)$$

From equation (13),

$$dV_{b1}/dt = \frac{aC(1-2\alpha_0)+i_3(1-\alpha_0)+\alpha_0 i_1}{C(k+1-2\alpha_0)}\left(\exp\left[-\frac{k+1-2\alpha_0}{k+1}t/T\right]-1\right) \quad (15)$$

which reduces to

$$dV_{b1}/dt \to \frac{aC - i_1}{C(1 - k)}\left(\exp\left[\frac{1 - k}{1 + k}\,t/T\right] - 1\right) \ldots\ldots (16)$$

as $\alpha_0 \to 1$.

Stage 5

When, at the end of stage 4, D_7 cuts off, the load nC is exposed and the emitter of X_2 is free to fall in potential. As this emitter is falling, V_{b1} is rising. Stage 5 is defined by the time between the release of D_7 and the turn on of D_4 as V_{b1} reaches ground potential.

We have $V_{b1} = (i_{x1}/pkC) + V_{b2}$

$$V_{b2} = (i_{x2}/pnC)$$

$$i_{x2} = i_{e1} + i_3 - i_7 - i_7$$

$$i_{e1} = pC(V_{b1} - V)$$

$$i_{x1} = i_{e2} - i_3 - i_{b1} = \alpha i_{e2} - i_3 - (1 - \alpha)i_{e1}$$

$$i_{e2} = i_7 + i_{x2}$$

from which can be derived

$$V_{b1} = \frac{pCV[n(1-2\alpha)+k]-i_3[n(1-\alpha)+k]-i_1(n\alpha-k)+ki_7}{pC\,[k(n+1)+n(1-2\alpha)]}$$

Upon substitution for α and re-arranging,

$$V_{b1}pC\left[p[k(n+1)+n]+\frac{k(n+1)+n(1-2\alpha_0)}{T}\right] - pCV\left[p(n+k)+\frac{n(1-2\alpha_0)+k}{T}\right] + i_3\left[p(n+k)+\frac{n(1-\alpha_0)+k}{T}\right] - i_1\left[pk-\frac{n\alpha_0-k}{T}\right] - ki_7(p+(1/T)) = 0$$

Initially, $V_{b1} =$, say, V_1 } These values can be computed
$dV_{b1}/dt =$, say, b } from equations (11), (13) and (15)
$V = 0$, $dV/dt = -a$,

the right-hand side of the equation thus becomes

$$C[k(n+1)+n](pV_1+b)+\frac{C[k(n+1)+n(1-2\alpha_0)]V_1}{T} - aC(n+k)+i_3(n+k)-k(i_1+i_7)$$

Now $\overline{V} = -(a/p^2)$, $\overline{i_3} = (i_3/p)$, $\overline{i_1} = (i_1/p)$, and $\overline{i_7} = (i_7/p)$,

so

$$\bar{V}_{b1}p^2C\left[p[k(n+1)+n]+\frac{k(n+1)+n(1-2\alpha_0)}{T}\right]+$$

$$aC\frac{[n(1-2\alpha_0)+k]}{T}$$

$$+i_3\frac{[n(1-\alpha_0)+k]}{T}+i_1\frac{n\alpha_0-k}{T}-(ki_7/T)=$$

$$pC[k(n+1)+n](pV_1+b)+\frac{pCV_1[k(n+1)+n](1-2\alpha_0)}{T}$$

which can be written $\bar{V}_{b1}=\dfrac{p^2V_1+pd+e}{p^2(p+f)}$

where $d=b+\dfrac{V_1[k(n+1)+n(1-2\alpha_0)]}{[k(n+1)+n]T}$

$$e=\frac{-aC[n(1-2\alpha_0)+k]-i_3[n(1-\alpha_0)+k]-i_1(n\alpha_0-k)+ki_7}{CT[k(n+1)+n]}$$

and $f=\dfrac{k(n+1)+n(1-2\alpha_0)}{[k(n+1)+n]T}$.

$$\therefore \bar{V}_{b1}=(e/p^2f)+\frac{df-e}{pf^2}+\left(V_1-\frac{df-e}{f^2}\right)\frac{1}{p+f}$$

and

$$V_{b1}=(e/f)\,t+\frac{df-e}{f^2}+\left(V_1-\frac{df-e}{f^2}\right)e^{-ft}\quad\ldots.\ (17)$$

As $\alpha_0\to 1$ this expression can be written

$$V_{b1}\to V_1+\frac{[(aC-i_1)(n-k)+k(i_7-i_3)]T}{C[k(n+1)-n]}\cdot(t/T)+$$

$$+\frac{T[k(n+1)+n]}{k(n+1)-n}\left[b-\frac{(aC-i_1)(n-k)+k(i_7-i_3)}{k(n+1)-n}\right]$$

$$\left(1-\exp\left[-\frac{k(n+1)-n}{k(n+1)+n}\cdot(t/T)\right]\right)..\ (18)$$

When calculating the next stage the values of V_{b2} and dV_{b2}/dt at the end of stage 5 will be needed. The value of i_{e2} throughout the switching period is also of interest as it may rise to a very high value.

For V_{b2}, we have

$$V_{b2}=-(i_{x2}/pnC)$$
$$i_{x2}=i_{e1}+i_3-i_1-i_7$$
$$i_{e1}=pC(V_{b1}-V)$$
$$V_{b2}=-\frac{pC(V_{b1}-V)+i_3-i_1-i_7}{pnC}$$
$$=-(V_{b1}/n)+(V/n)+(1/nC)\int_0^t i_7+i_1-i_3$$
$$\therefore V_{b2}=-(V_{b1}/n)+(T/nC)(i_7+i_1-i_3-aC)\,t/T\quad\ldots.\ (19)$$

where V_{b1} may be obtained from equation (17).

For dV_{b2}/dt, we have, differentiating equation (19)

$$(dV_{b2}/dt)=-(dV_{b1}/ndt)+(1/nC)(i_7+i_1-i_3-aC)$$

From equation (17),

$$(dV_{b1}/dt)=(e/f)-f\left(V_1-\frac{df-e}{f^2}\right)e^{-ft}$$

$$\therefore dV_{b2}/dt=f\left(V_1-\frac{df-e}{f^2}\right)$$
$$e^{-ft}-(e/f)+(1/nC)(i_7+i_1-i_3-aC)\quad\ldots.\ (20)$$

Now $V_{b2}=-(i_{x2}/pnC)$

$\therefore i_{x2}=-nC(dV_{b2}/dt)$

Also, $i_{e2}=i_7+i_{x2}$

$$\therefore i_{e2}=i_7-nCf\left(V_1-\frac{df-e}{f^2}\right)e^{-ft}+(nCe/f)-i_7-i_1+i_3+aC$$

$$=(nCe/f)-nCf\left(V_1-\frac{df-e}{f^2}\right)e^{-ft}-i_1+i_3+aC\quad(21)$$

Stage 6

At the end of stage 5, D_4 conducts, thereby placing an effective short-circuit between X_1 emitter and ground and also arresting the rise of V_{b1}. At this time switching is completed since the input waveform can be removed without harm. It remains for the potential V_{b2} to fall from that given by equation (19) at time t_5 to ground potential.

We have

$$V_{b2}=-(i_{x2}/pnC)\quad:\quad i_{x2}=i_{e2}-i_7$$
$$i_{e2}=(i_{b2}/(1-\alpha))\quad:\quad i_{b2}=i_{c1}-i_1-i_{x1}$$
$$i_{c1}=(\alpha/(1-\alpha))\,i_b\quad:\quad i_{b1}=i_{e2}-i_3-i_{x1}$$
$$i_{c2}=\alpha i_{e2}\quad:\quad i_{x1}=-pkCV_{b2}$$

Combining these expressions,

$$V_{b2}=\frac{i_7(1-2\alpha)+\alpha i_3+i_1(1-\alpha)}{pC[n(1-2\alpha)+k]}$$

Upon substituting for α, this becomes

$$V_{b2}p\left[p+\frac{n(1-2\alpha_0)+k}{(n+k)T}\right]-\frac{i_7}{C(n+k)}\left(p+\frac{1-2\alpha_0}{T}\right)-$$

$$\frac{\alpha_0 i_3}{CT(n+k)}-\frac{i_1}{C(n+k)}\left(p+\frac{1-\alpha_0}{T}\right)=0$$

Initially $V_{b2}=$, say, V_2, from equations (17) and (19)

$dV_{b2}/dt=$, say, v_2, from equation (20)

Substituting these initial conditions,

$$\bar{V}_{b2}p\left[p+\frac{n(1-2\alpha_0)+k}{(n+k)T}\right]-p\frac{\bar{i}_7+\bar{i}_1}{C(n+k)}-$$

$$\frac{\bar{i}_7(1-2\alpha_0)+\alpha_0\bar{i}_3+\bar{i}_1(1-\alpha_0)}{CT(n+k)}=$$

$$pV_2+v_2+\frac{n(1-2\alpha_0)+k}{(n+k)T}V_2-\frac{i_7+i_1}{C(n+k)}$$

Now $\bar{i}_7=(i_7/p)$, $\bar{i}_1=(i_1/p)$, $\bar{i}_3=(i_3/p)$

So $\bar{V}_{b2}p^2\left[p+\dfrac{n(1-2\alpha_0)+k}{(n+k)T}\right]-\dfrac{i_7(1-2\alpha_0)+\alpha_0 i_3+i_1(1-\alpha_0)}{CT(n+k)}=$

$$p^2V_2+p\left(v_2+\frac{n(1-2\alpha_0)+k}{(n+k)T}V_2\right)$$

whence

$$\bar{V}_{b2}=(V_2/p)+\frac{T(n+k)}{n(1-2\alpha_0)+k}\left[v_2-\frac{i_7(1-2\alpha_0)+\alpha_0 i_3+i_1(1-\alpha_0)}{C[n(1-2\alpha_0)+k]}\right]$$

$$\left[1/p-\frac{1}{p+\dfrac{n(1-2\alpha_0)+k}{(n+k)T}}\right]+\frac{i_7(1-2\alpha_0)+\alpha_0 i_3+i_1(1-\alpha_0)}{p^2C[n(1-2\alpha_0)+k]}$$

the transform of which is

$$V_{b2}=V_2+\frac{T(n+k)}{n(1-2\alpha_0)+k}\left[v_2-\frac{i_7(1-2\alpha_0)+\alpha_0 i_3+i_1(1-\alpha_0)}{C[n(1-2\alpha_0)+k]}\right]\times$$

$$\left[1 - \exp\left\{-\frac{n(1-2\alpha_o)+k}{(n+k)T}\,t/T\right\}\right] + \frac{[i_7(1-2\alpha_o)+\alpha_o i_3+i_1(1-\alpha_o)]T}{C[n(1-2\alpha_o)+k]}\,t/T \quad \ldots\ldots\ldots\ldots \quad (22)$$

which, as $\alpha_o \to 1$, reduces to

$$V_{b2} = V_2 - \frac{T(n+k)}{n-k}\left[v_2 - \frac{i_7-i_3}{C(n-k)}\right]\left[1 - \exp\left\{-\frac{n-k}{n+k}t/T\right\}\right] + \frac{i_7-i_3}{C(n-k)}\,t/T$$

The emitter current of the pnp transistor during this stage is given by $i_{e2} = i_7 - nC\,(dV_b/dt)$ which, from equation (22) becomes

$$i_{e2} = i_7 - n\left[\frac{i_7(1-2\alpha_o)+\alpha_o i_3+i_1(1-\alpha_o)}{n(1-2\alpha_o)+k}\left(1 - \exp\left\{-\frac{n(1-2\alpha_o)+k}{n+k}\,t/T\right\}\right) + v_2C\exp\left\{-\frac{n(1-2\alpha_o)+k}{n+k}\,t/T\right\}\right] \quad \ldots\ldots\ldots\ldots \quad (23)$$

which, as $\alpha_o \to 1$, reduces to

$$i_{e2} = i_7 - n\left[\frac{i_7-i_3}{n-k}\left(1 - \exp\left\{-\frac{n-k}{n+k}\,t/T\right\}\right) + v_2C\exp\left\{\frac{n-k}{n+k}\,t/T\right\}\right]$$

If equations (22) and (23) are computed using typical values for the various parameters it is found that the current through the structure can be as high as several hundreds of milliamperes. The presence of base spreading resistance will cause bottoming of one or both transistors to ensue. If the value of base spreading resistance is known the potential at which bottoming will commence can be predicted.

Once bottoming occurs the operation of the circuit is modified. Several approaches are possible to calculate the ensuing potentials and currents, but one only will be treated here. This is the easiest case: it assumes both transistors bottom simultaneously when the potential across the structure is at V_3 volts.

The circuit then degenerates to a capacitor with stored charge nCV_3 across which is a resistance of value $r_b'/2$. (This assumes the voltage drop $\frac{(i_7 - i_3)r_b'}{2}$ can be neglected).

The potentials V_{b2} then falls as

$$V_{b2} = V_3\exp[-(2t/nCr_b')] \quad \ldots\ldots\ldots \quad (24)$$

and the current through the emitter of the pnp transistor is given by

$$i_{e2} = i_7 + (2V_3/r_b')\exp[-(2t/nCr_b')] \quad \ldots\ldots \quad (25)$$

(To be continued)

Vehicle Speed Measuring Equipment

An electronic vehicle speed measuring equipment incorporating fifty-four transistors has been developed by Venner Electronics Limited, and is at present receiving consideration by the Metropolitan Police who are testing the device on outer London roads.

The equipment was primarily developed for the Road Research Laboratories of the D.S.I.R. and is basically a device for measuring small intervals of time to a high degree of accuracy. Attached to the electronic elapsed time indicator are two rubber tubes long enough to span the road, each of which is connected to a pressure switch. The two tubes are layed across the road at right-angles to the traffic flow and spaced a little under six feet apart (70·4in).

To measure the speed of an approaching vehicle all that is required is to set the equipment to 'Ready'. Immediately the front wheels of the vehicle cross the first tube the pressure switch starts the timer. As soon as the wheels cross the second tube the timer stops. The elapsed time is recorded by the meters. The reading obtained remains on the meters until the equipment is manually reset.

It is expected that the rubber tubes may be laid semi-permanently at points known to be black spots and the equipment plugged in from time to time which would discourage motorists from exceeding speed limits and so contribute to road safety.

The equipment incorporates a crystal oscillator operating at 10kc/s as the basic time element. The output of this unit is passed to two binary dividers to give a 2·5kc/s signal which is in turn fed to a gating circuit. The gate is opened by the passing of a vehicle over the first strip and closed by the vehicle passing over the second strip. The number of pulses passing through the gate while it is opened are counted by three decade counting stages with digital presentation on meters calibrated from 0-9. If, for example, the first meter indicates 3, the second 4 and the third 5, then this is the interval of time in 0·4msec steps which elapsed while the vehicle traversed the measured distance of 70·4in. The frequency and distance are chosen so that the resultant indication may be divided into 10 000 giving the speed of the vehicle. Thus, in the case given the speed corresponds to 29 mile/h. The accuracy is ± 1 count for any figure recorded and thus at 30 mile/h (indication 333) the accuracy is to approximately $\pm\frac{1}{2}$ per cent. At 100 mile/h (indication 100) the accuracy is to within ± 1 per cent. The equipment is completely portable, batteries being included in the case which measures 13in by 9in by 7in.

The speed measuring equipment in use.

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The device is known as "BESI" (Bus Electronic Scanning Indicator) and will enable each bus on a route to transmit an identification number.

The overall view of the buses gained by the electronic method will enable the controllers to take quick remedial action when a route's regularity is upset through traffic.

The main difficulty in operating a regular bus service through the congested streets of a city is the lack of knowledge where individual buses are at any instant of time, and whether any acute congestion has built up in any particular area, but to give a complete picture of bus operation on London Transport entails the tracing of some 7 000 buses operating on some 500 routes.

A variety of schemes have been tried out, including magnetic scanning and local radio intercommunication, but bearing in mind the cost involved to cover the whole of the London Transport area, a simple optical system has finally been chosen.

The scheme which is now in process of development consists of a number of check points along each route which, by electronic equipment, reads the number of each bus as it passes the point and transmits it over telephone wires to a central location, where it is displayed on a panel and finally will be recorded on a chart. When each bus passes the next check point the number will be recorded on another panel and cancelled on the first, so that in effect each panel will contain the running number of each bus between the two boundary check points.

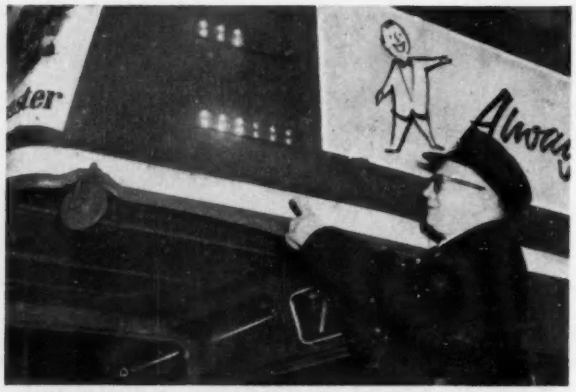

Fig. 1. The reflectors mounted above the driver's cab

Numerically, the largest item will be the equipment necessary on each of the 7 000 buses, and for this reason this item has been designed so as to be as cheap as possible; moreover, equipment on a moving bus is difficult to maintain so that it was decided only a form of reflecting plate would be suitable.

Some of the other more important factors that had to be considered in the design of the system were as follows:

(a) The equipment designed to facilitate quick and easy changes of route and running number.

(b) The bus equipment in no circumstances to interfere with the ordinary functioning of the bus, or its crew.

(c) The road-side equipment easily installed and maintained.

(d) The System capable of being operated by day and by night, over a range of bus speeds from one to thirty miles per hour.

General Description

The pilot system is now being tried out in service on a bus route which has been divided into four sections each with a scanning equipment for reading in either direction.

Each bus running number has been coded into a binary number and this has been reproduced on a plate containing reflectors for each digit, and a corresponding blank for each zero. The plate has been placed on the nearside of the bus towards the front, above the driver's cab, as shown in Fig. 1.

The scanning equipment has been erected at the same height as the bus plate and as near as possible to the roadway, either on a post at the pavement edge, or where the side-walk is narrow, on a convenient point on the building line.

The equipment consists of a source of modulated light focused on to the plates of the buses, and a further optical system to receive back the reflected light. As each reflector passes the beam of light, the reflected light falls on to a photo-electric cell and the resultant pulses are amplified shaped and transmitted by line to the control point.

At the control point, the incoming pulses operate relays which will build up the binary number of the bus, and when completed, will close the circuit, causing the actual running number to be illuminated on the check point display panel.

The panels of each check point are so wired that as each number comes up on one panel, the number on the previous panel is cancelled. The general layout is shown diagrammatically in Fig. 2.

BUS EQUIPMENT

As stated above, the equipment mounted on the bus consists of a plate containing reflectors representing the running number of the bus in binary form.

There are several problems to be overcome in designing the plate. Firstly, there is the difficulty of recording buses travelling at any speed between one and thirty miles per hour; secondly, there is the variation in the height of the reflectors, due to the loading of the bus, and, thirdly, there is the variation of angle of the reflectors from the vertical due to the position of the bus on the camber of the road as it passes the scanner. Added to the above is the requirement that the plates must be of reasonable size, not only for handling purposes—as they are changed every time a bus alters its running number—but also because there is little space on the bus not already occupied by destination blinds, advertising spaces and windows. Moreover, the plates must be placed at a height, well above the level of pedestrians on the side walk and, maybe, cars parked at the kerb.

The most suitable form of reflector has been found to be the type used for road signs, generally referred to as 'cats eyes'. These are $\frac{3}{4}$in in diameter and can be designed for a very narrow reflecting field and negligible scatter.

To compensate for varying speeds of the bus, the plate is produced in two parts, the upper half being a complete row of reflectors to form a timing base—plus one additional one at the end to act as a clear down unit. The lower half is placed 10in lower, and exactly in line vertically is the binary code plate. The horizontal spacing between each reflector is 2in, which has been found satis-

factory for timing purposes up to at least forty miles per hour, leaving a reasonable margin for normal bus operation.

To compensate for both loading and camber, the reflectors are mounted in pairs, one above the other at 1in centres.

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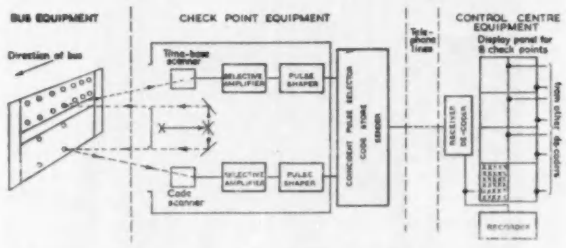

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The scanner is designed to reject all signals other than those contained in the reflectors, particularly the gold lettering and other reflecting vertical lines often seen on trade vehicles.

It must also work in bright sunlight as well as on dark nights—it is also hoped that it will operate so long as the buses themselves can be operated in a fog.

The scanner (shown in Fig. 3) consists of a light source consisting of a 12V, 36W lamp, which is focused by lenses and passed through slots on a rotating disk, the number of slots and the speed of its rotation results in the light being modulated at 3kc/s. These light pulses are passed to two mirrors set at right-angles, which divide the beam into two, and by further mirrors deflected one on to the time-base plate and the other on to the coding plate on the bus itself.

The light reflected from these plates is passed into the scanner once more and focused on to two photo-sensitive transistors which transform the light pulses into electrical pulses which are then passed to resonant amplifiers. These reject the effect of all extraneous incoming light not associated with that sent out by the instrument's lamp at the controlled frequency, and therefore not part of the bus identification.

Neither the 3kc/s modulation nor the waveform of the resulting signals would be suitable for operating the telephone-type circuits which follow, so that they are passed into pulse shaping transformers where a square wave shaped pulse is produced from each signal from the reflectors.

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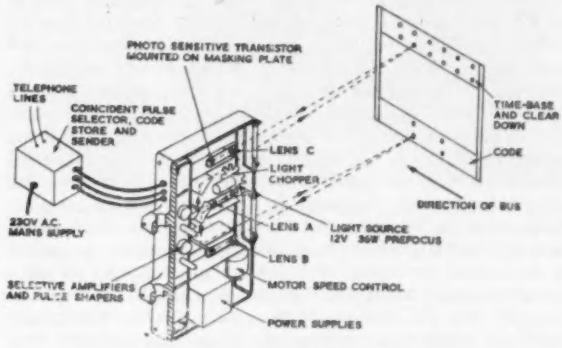

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The stored binary number at the scanning point is fed into the line, as soon as a clear channel is available by normal pulsing procedure, and the pulses are again stored on relays at the centre, and when built up, energize the lamp with the running number corresponding to the code.

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The equipment is in its primary development stage and there will no doubt be many improvements to be made over the next few months, but it is expected that it will at least enable some improvement in service regularity to be achieved in spite of the extremely difficult conditions which have arisen as a result of street congestion.

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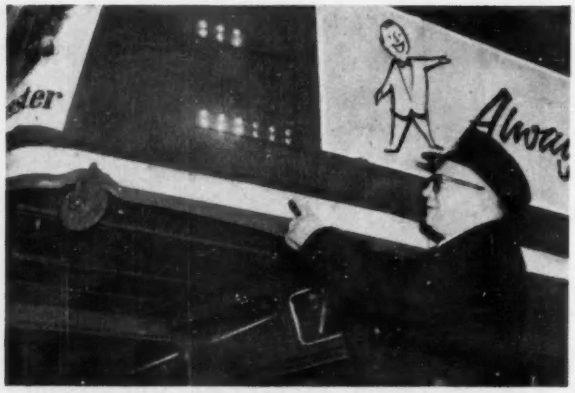

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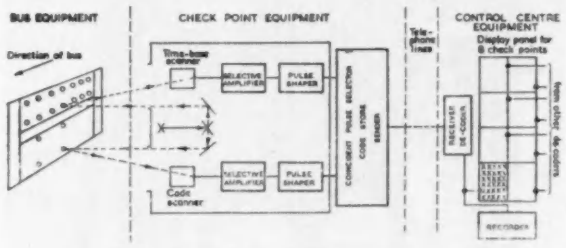

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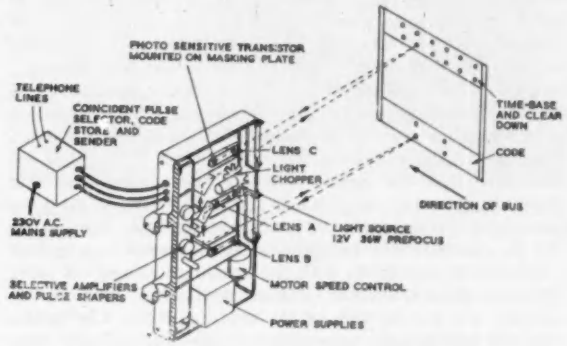

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A New Electronic Assembly System

By H. C. Bertoya*, A.M.Brit. I.R.E.

MANY new mass production techniques have been evolved for electronic and allied equipments over the last few years; but the method of construction of apparatus in laboratories has hardly altered. The usual method is, of course, to take a sheet of aluminium and to make an intelligent guess at the number and position of holes likely to be required. The metal work is then carried out and the sheet is bent to form either a box or a channel; the sides of the box serving to protect the components when the box is laid on the bench. Usually more holes have to be made after the main components have already been attached. If this is impossible, components have to be removed so that the metal work may be carried out. The chassis is, however, unusable in its normal horizontal position since the components are not accessible. Because of this the chassis is often stood on end, or propped up against a convenient text-book, with the attendant danger to valve top-caps, etc., when the chassis slips over. If a circuit spreads over the confines of the area available, 'Christmas-trees' of components appear which are mechanically very unstable. If the device is fairly complex, either a great number of functional units must be built on one chassis (which tends to make confusion worse confounded) or numbers of small chassis are arrayed on the bench top. In general the normal methods are unsatisfactory and a great deal of design time is spent, not in improving or testing the electrical circuit, but in carrying out makeshift repairs to a ramshackle set-up. The obvious waste of time in the writer's own laboratory caused him to reconsider constructional techniques and to design a method which would aid the construction of circuits and complete electronic systems. It is now being marketed under the name of 'Rapikon.'

Existing Methods of Unit Construction

An aid to rapid construction is the 'unit' system. Some systems have been described[1,2] which have admirable features. Their 'box-chassis/front-panel' approach was, however, rejected. The fundamental problem is not that of constructing a conventional chassis by means of standard parts. The problem is, rather that of finding the best means of supporting circuit components, having regard to the purpose which that circuit has to serve.

As the design proceeded it was soon apparent that many compromises would have to be made between the conflicting requirements of temporary and permanent equipment. It was, therefore, decided to concentrate solely on facilitating the experimental construction and proving of circuits and systems, although this does not prevent the construction of permanent equipment if it is thought necessary.

In fact, there is no great virtue in saving a day's construction time in a 'one-off' equipment if it is to serve for a couple of years; and the price that is paid for a unit or 'modular' system (expense, space and lack of complete flexibility) is unnecessarily high for production models. In any case, the important thing is to develop a circuit which functions well. Problems of mechanical construction are more properly the province of the production engineer and can follow on only after the successful completion of the electrical development stage.

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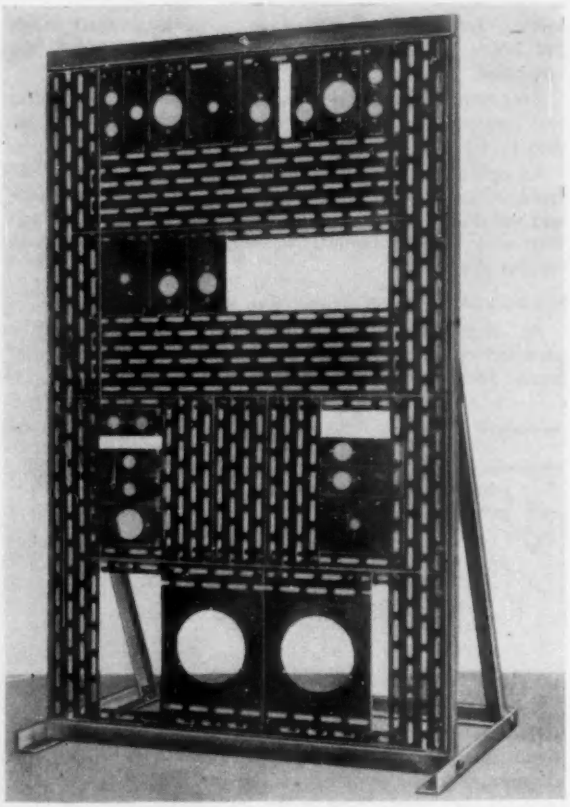


A typical 'chassis' assembly.

Requirements of a Desirable Method

After experimenting with several methods of layout and construction, the most important requirements were found to be as follows:—

(1) Circuits and their supports should be capable of modification and growth exactly in accordance with the evolution of the design in the engineer's mind.
(2) Complete systems as well as single circuits should be accommodated, preferably as 'block diagrams'.
(3) The working surfaces should be disposed in such a manner as to provide maximum accessibility and to allow the engineer to work comfortably.
(4) Metal-work should not have to be done.
(5) The form of mechanical layout should be such as to encourage neat and orderly construction. This is an important—though not often considered—point, and one which is less likely to produce wrong answers for irrelevant electrical reasons (bad or mistaken connexions, incorrect components, unnecessarily long leads, etc.)

The New Method of Construction

The method of construction finally developed consists of the following component parts:—

The Holder Plates

These are specially punched to hold potentiometers, valveholders, switches, terminals, plugs and sockets, meters, etc. They are made from 20 s.w.g. plated mild steel. Each holder plate is movable in the plane of the chassis and has a pronged end for sliding on to a 'slotted plate'. The other end is fixed with a nut and bolt to ensure good electrical connexion. The pronged end means that direct access to

the point of fixing is not required: holder plates may be removed and replaced without disturbing overlapping wiring or tag panels, etc. Aluminium holder plates are also provided for special components for which the punched plates are not available.

The Slotted Plates and Girders

These may be assembled in a variety of ways, in general forming a rectangular frame 14½in wide. The plates are also used to take components for which the special holder plates are not required, e.g. tag panels, terminal blocks, etc., etc. The slotted plates and girders are assembled in such a way as to leave constant-width gap in a convenient position. Into this gap are inserted the holder plates.

The largest slotted plate is 3in wide; a large quantity of tag panels and components were measured and it was found that this width would accommodate the majority of them. The fixing of a plate at right-angles to the main cross-piece enables power inputs to be conveniently connected to terminal blocks.

The Rack

This is a heavy mild steel rack about 25in high and 15in wide. It has tapped holes in the uprights and it can be screwed to the bench if necessary.

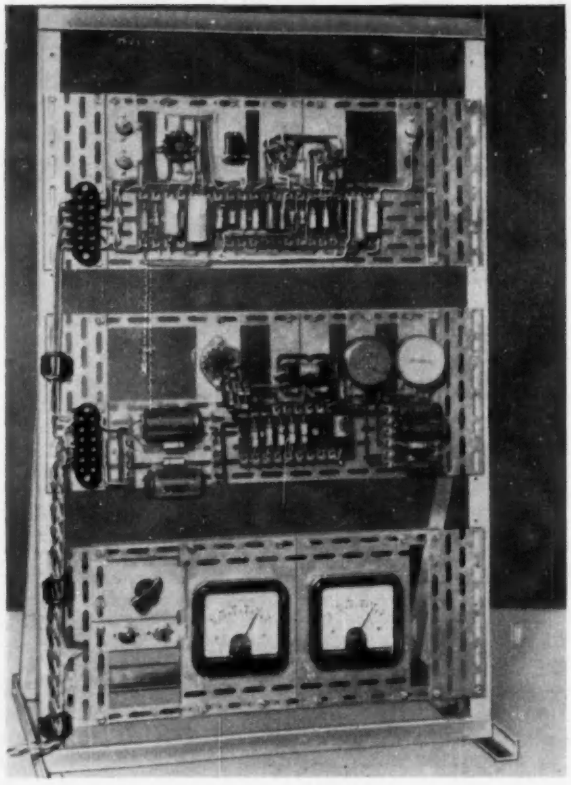
Assembly

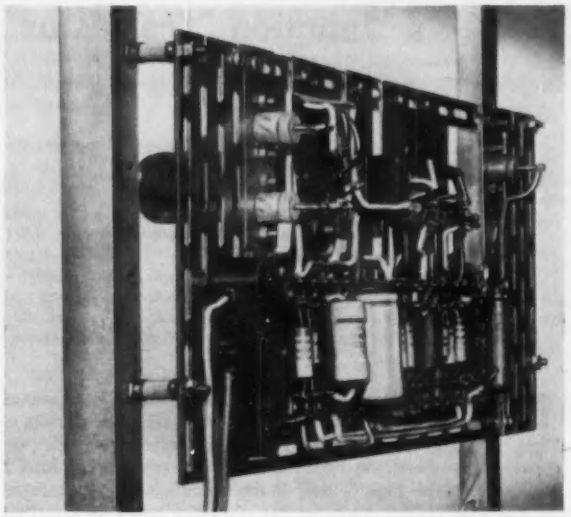
A complete chassis consists of a frame made up from slotted plates and girders, on which are mounted the holder plates. The complete chassis is bolted to the rack.

Conclusion

It is thought that the system conforms fairly closely to the ideal one described under the heading 'Requirements of a desirable method'. Using the same paragraph numbers, the way in which the requirements are satisfied is discussed, as are also some additional advantages which result.

A complete unit.





A unit mounted with components and wiring points facing the front. Since this particular chassis was at an elevated potential, it was mounted on insulators.

(1) Modifications are simple since the 'holes' (i.e. the holder plates) are movable. Chassis may be increased in size by simply altering the size of members or by bolting on extensions. New holder and other plates are to be made as the need arises.

(2) The 14½in width of the basic chassis was the result of experiment. It is the optimum size for most circuits without being too large to prevent the construction of single functional units, e.g. *RC* oscillators, time-bases, gates, etc. Each chassis can form a block of the system block diagram and may be quickly removed and replaced. An improved version of a particular block may be constructed separately and inserted into the system, thus causing minimum disruption of work on the system as a whole.

(3) The working surfaces are held in the vertical plane by the rack. The rack is heavy enough to allow work to be done without shifting. Chassis are held firmly and compactly—the vertical plane means a saving in bench space since the chassis are stacked—and flying leads between chassis are short and do not become displaced (one chassis cannot move in relation to another). When a circuit has been developed and found to be satisfactory there is no cause further to refer to the wiring points which face the experimenter. The chassis may then be reversed on the rack so as to bring all controls to the front.

(4) Metal work is eliminated; in addition there is no scrap since the items may be re-used.

(5) The standard of 'mock-up' construction has certainly improved since the introduction of the system.

Although specifically designed for experimental work, semi-permanent laboratory test gear has been constructed on Rapikon. When not in use it is stored by sliding into special holders. The system has been in use for some time and has proved extremely satisfactory.

Acknowledgment

The writer thanks Messrs. Shandon Electronics Ltd for permission to publish this article.

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A 1kc/s Junction Transistor T-Parameter Measurement Set

By R. A. Hall*, B.Sc.

A set has been constructed for measurement of the parameters of the simple T-equivalent circuit of a junction transistor at a frequency of 1kc/s. A description of the set is given, together with the experimental procedure.

The simple equivalent circuit at 1kc/s is discussed. Experiments so far indicate that serious frequency-dependent errors in measurement of $r_e(1-\alpha)$, $C_c/(1-\alpha)$, and, to a lesser extent, r_e are likely to occur in the case of many low frequency transistors, but not generally in the case of transistors with $f_{c\alpha}$ in the megacycle region. These errors are caused by omission of certain reactive elements from the equivalent circuit and, in the case of r_e, the fact that the inner end of capacitor C_c is connected not to the internal node as in the simple circuit, but to some point along the base resistance. The errors can be avoided by reduction of the measurement frequency to about 200c/s.

THE set, together with certain additional equipment, consists essentially of three circuits which are shown in Figs. 1, 2 and 3 with bias supplies connected as for a pnp transistor and will be referred to as Circuits 1a, 1b and 2 respectively. In Figs. 1 and 2 the transistor is represented by the appropriate form of the simple T-equivalent circuit whose parameters are measured and a discussion is given later on the validity of this equivalent circuit.

The measurements which can be made using each of these circuits are as follows:

Circuit 1a r_e, C_c, r_b.

Circuit 1b $r_e(1-\alpha)$, $C_c/(1-\alpha)$, r_e where $\alpha = \alpha_{ce}$

Circuit 2 α_{cb} or $\alpha/(1-\alpha)$

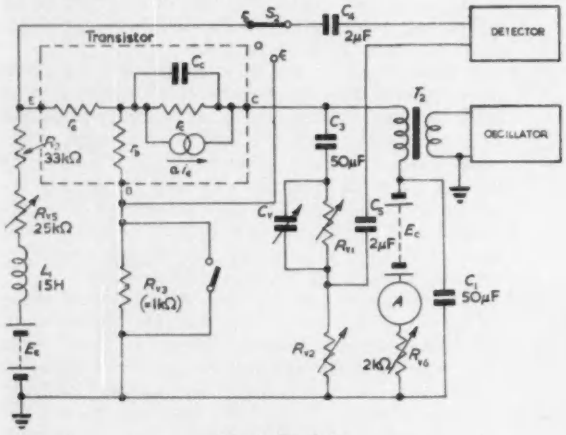

Fig. 1. Circuit 1a

A description of the three measurement circuits is given together with the experimental procedure in each case and this is followed by a description of the complete circuit of the measurement set.

CIRCUIT 1A.

The transistor is placed in a bridge circuit and the impedance in the emitter circuit is very high so that when an alternating voltage is applied in series with the base-collector bias voltage the effect of the internal current generator αi_e due to feedback current in the emitter circuit may be neglected. It is estimated that the reduction in output impedance due to this effect should be less than 5 per cent for most transistors so that the emitter may be considered to be on open-circuit.

The procedure is to set switch S_2 to r_c, R_{v3} to 1kΩ and R_{v2} to 10Ω, then a balance is obtained by adjustment of R_{v1} and C_v. The basic circuit is then as shown in Fig. 4 for which, neglecting r_b in comparison with r_e and the reactance of C_c, the balance conditions are

$$r_c/1000 = (R_{v1}/10) \text{ or } r_c = 100 \,.\, R_{v1} \quad \ldots\ldots (1)$$

and similarly

$$C_c = (1/100) \,.\, C_v \quad \ldots\ldots\ldots\ldots (2)$$

but the variable capacitor must be calibrated against known values of capacitance in place of a transistor in order to allow for residual capacitances.

Next R_{v3} is reduced to zero and switch S_2 set to r_b and a second balance obtained by adjustment of R_{v2} and C_v but leaving R_{v1} at its previous setting. The basic circuit is then as shown in Fig. 5, for which the balance condition is

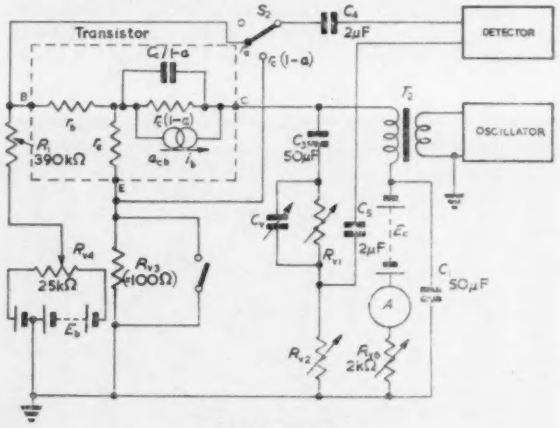

Fig. 2. Circuit 1b

$$r_c/r_b = (R_{v1}/R_{v2})$$

and by substituting for R_{v1} from equation (1)

$$r_b = 100 \,.\, R_{v2} \quad \ldots\ldots\ldots\ldots (3)$$

CIRCUIT 1B

The transistor is placed in a bridge circuit similar to Circuit 1a except that the alternating voltage is applied in series with an emitter-collector bias voltage and the impedance in the base circuit is very high so that the effect of the internal current generator $\alpha_{ob} i_b$ due to feedback current in the base circuit may be neglected. It is estimated that the increase in output impedance due to this effect should not exceed 5 per cent for most transistors so that the base may be considered to be on open-circuit.

The procedure is to set switch S_2 to $r_e(1-\alpha)$, R_{v3} to 100Ω and R_{v2} to 100Ω then a balance is obtained by adjustment of R_{v1} and C_v. The basic circuit is then as shown in Fig. 6 for which, neglecting r_e in comparison with

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$r_c(1-\alpha)$ and the reactance of $C_c/(1-\alpha)$ the balance conditions are

$$\frac{r_c(1-\alpha)}{100} = R_{v1}/100 \text{ or } r_c(1-\alpha) = R_{v1} \quad \ldots\ (4)$$

and similarly

$$C_c/(1-\alpha) = C_v \quad \ldots\ (5)$$

but again allowance must be made for residual capacitances.

Next R_{v3} is reduced to zero (taking care to re-adjust base bias current by means of R_{v4}) and switch S_2 set to r_e and a second balance obtained by adjustment of R_{v2} and C_v, but leaving R_{v1} at its previous setting. The basic circuit is then

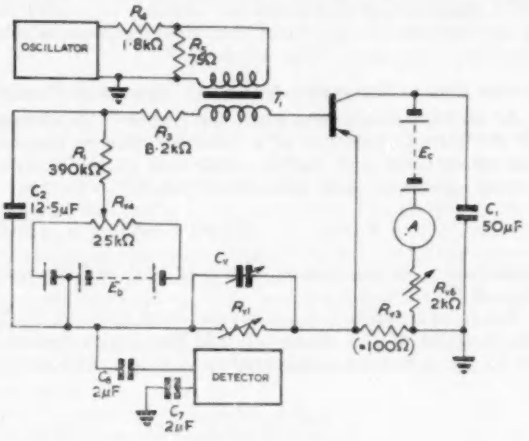

Fig. 3. Circuit 2

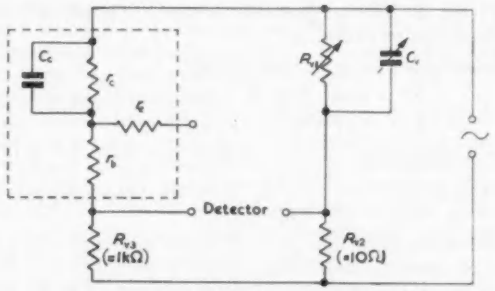

Fig. 4. Basic circuit of Fig. 1 (first balance)

as shown in Fig. 7 for which the balance condition is

$$\frac{r_c(1-\alpha)}{r_e} = R_{v1}/R_{v2}$$

and by substituting for R_{v1} from equation (4)

$$r_e = R_{v2} \quad \ldots\ (6)$$

CIRCUIT 2

The transistor is placed in a common-emitter circuit in which an alternating component is added to the base bias current and a collector load of 100Ω is inserted in order to measure the alternating component of collector current under approximately short-circuit conditions. Due to the approximate 180° phase difference between base current and collector current a null can be obtained in the detector by adjustment of R_{v1} and C_v (taking care to re-adjust base bias current after each large change in the value of R_{v1}). The null condition is

$$\alpha_{cb} = \frac{\text{impedance of combination of } R_{v1} \text{ and } C_v}{100} \quad \ldots\ (7)$$

In general the phase of α_{cb} is so small at 1kc/s that the effect of the reactance of C_v may be neglected, the exceptions being mainly low frequency transistors with high current gains such as the Brimar TJ3 whose parameters are discussed later.

Complete Circuit

The complete circuit diagram is shown in Fig. 8. The measurement set panel contains Post Office type jacks for

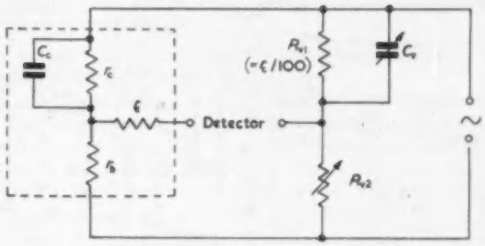

Fig. 5. Basic circuit of Fig. 1 (second balance)

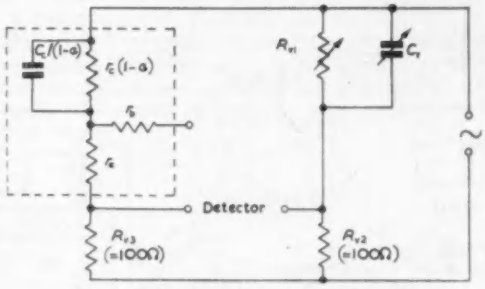

Fig. 6. Basic circuit of Fig. 2 (first balance)

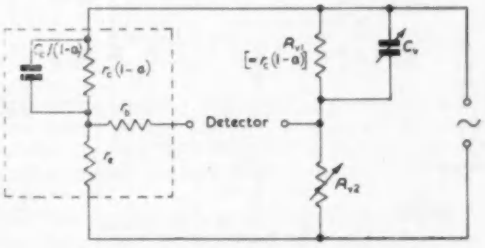

Fig. 7. Basic circuit of Fig. 2 (second balance)

R_{v1}, C_v, generator (GEN) and detector (DET) and also terminals for R_{v2}, external position of R_{v3} switch, bias supplies, collector current meter and the transistor under test.

In order to obtain one of the three measurement circuits it is necessary to insert the R_{v1}, C_v, DET and GEN plugs in the appropriate jacks marked (1) for Circuits 1a and 1b and in jacks marked (2) for Circuit 2. The transistor plug must be inserted in jack J_1, J_2 or J_3 for Circuit 2, 1b, 1a respectively. Switch S_3 is provided as a means of reversing bias supply and meter connexions so that measurements may be made on both pnp and npn transistors and the bias supplies are switched on by setting switch S_1 to the appropriate position.

Adjustment of collector bias current is made by means of R_{v5} in Circuit 1a and R_{v4} in Circuits 1b and 2, and fine adjustment of collector bias voltage is made by means of R_{v6}. The collector bias voltage should be measured with a high impedance voltmeter between base and collector in Circuit 1a and between emitter and collector in Circuits 1b

and 2 and in order to ensure that conditions in each circuit are identical it is necessary to measure also the voltage between emitter and base which may be appreciable in some cases.

The additional equipment used is as follows:

R_{v1} 0 to 1MΩ in 10Ω steps.

R_{v2} 0 to 1kΩ in 0·01Ω steps (Sullivan dual-dial resistance box)

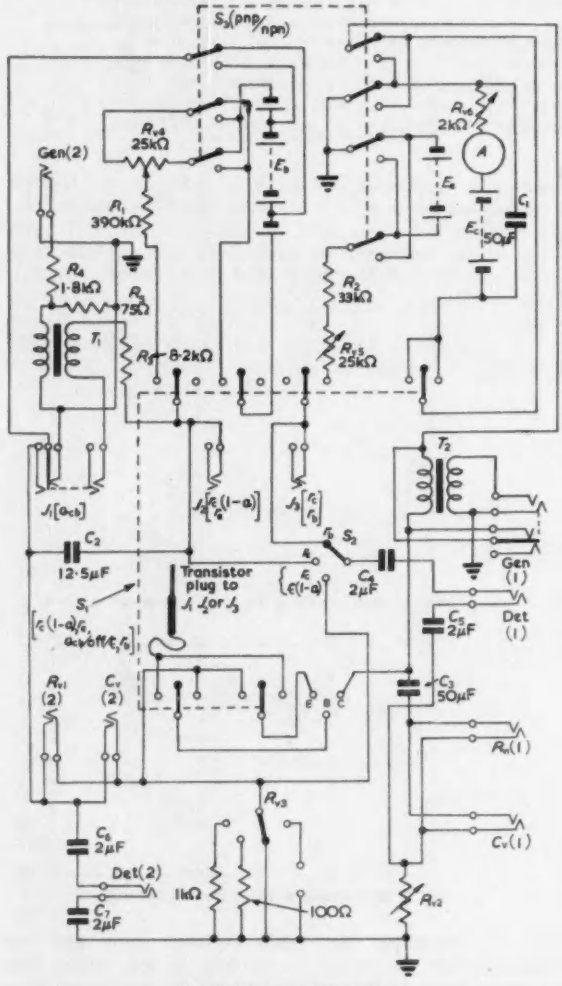

Fig. 8. The complete circuit

C_v Range of 50pF to 0·1μF covered continuously. 50 to 500pF (Variable) (+ about 30pF residual capacitance in plug and leads)

100 to 1 500pF (Variable)
0 to 0·1μF in 1 000pF steps (Decade Box) } *

* (+ about 100pF residual capacitance with two connected in parallel).

GENERATOR

Ediswan l.f. oscillator having at maximum output an e.m.f. of about 20V peak-to-peak with an output impedance of 10kΩ.

DETECTOR

Tuned transistor differential amplifier as described elsewhere[1].

Transformers T_1 and T_2 are each Fortiphone Type EX45 having a primary inductance of 15H and a turns ratio of 7·1/1 from primary to secondary. Each transformer is connected for voltage step-down from oscillator to bridge so that when the oscillator output is set to maximum the voltage across the bridge arms is about 2·5V peak-to-peak and the base current alternating component in Circuit 2 is about 2μA peak-to-peak.

It is realized that functionally the measurement set could be greatly simplified by replacement of separate plugs and switches by a multi-gang switch. However the set was designed initially not for use by unskilled operators, but for laboratory work in which it is important that measurement equipment should be flexible and easy to modify and it was considered that functional simplifications of that type would not serve these interests.

Errors Due to Incomplete Transistor Equivalent Circuit

At very low frequencies where the frequency dependence of the internal generator of a transistor may be neglected one obtains, for the output admittance in the common emitter connexion with open-circuit base,

$$Y_{out} = \frac{1}{1-\alpha}\,[(1/r_c) + j\omega C_c] \quad \ldots\ldots\ldots \quad (8)$$

neglecting r_e in comparison with $r_c(1-\alpha)$ and the reactance of $C_c/(1-\alpha)$.

For most transistors $f_{c\alpha}$ is not less than 100kc/s, so that the variation of α in magnitude and phase with frequency up to 1kc/s may be represented to a good approximation by

$$\alpha = \frac{\alpha_o}{1 + j\omega/\omega_{c\alpha}} \quad \ldots\ldots\ldots\ldots\ldots \quad (9)$$

where $\omega_{c\alpha} = 2\pi f_{c\alpha}$

This is the same current which one would obtain by feeding from the current generator through a single RC stage to the collector circuit.

Substituting for α in equation (8)

$$Y_{out} = \left\{\frac{(1 - \alpha_o + \omega^2/\omega_{c\alpha}{}^2) - j\alpha_o(\omega/\omega_{c\alpha})}{(1-\alpha_o)^2 + (\omega/\omega_{c\alpha})^2}\right\} \cdot [(1/r_c) + j\omega C]$$

Hence, neglecting $\omega^2/\omega_{c\alpha}{}^2$ in comparison with $(1-\alpha_o)$

$$Y_{out} = \left\{\frac{(1-\alpha_o) - j\alpha_o(\omega/\omega_{c\alpha})}{(1-\alpha_o)^2 + (\omega/\omega_{c\alpha})^2}\right\} \cdot [(1/r_c) + j\omega C] \quad \ldots\ldots \quad (10)$$

The main effect due to the complex nature of α is therefore to cause a reduction of output capacitance and resistance below the very low frequency values given by equation (8), the percentage changes in output capacitance and resistance depending on the values of $\omega/\omega_{c\alpha}(1-\alpha_o)$ and $\omega C_c r_c$ at the frequency of measurement. The measurements in Table 1 made on two Brimar junction transistors indicate the error experienced in practice, although the TJ3 is considered to have a fairly extreme value of $f_{c\alpha}(1-\alpha_o)$.

In Table 2 are given the calculated values of output impedance in Circuit 1b using equation (10) based on measured values of output impedance in Circuit 1a, α_{cb} in Circuit 2 (assumed $= \alpha_o$) and $f_{c\alpha}$.

The error in calculated values of r_{out} and C_{out} is observed to be not greater than about 10 per cent which is considered satisfactory.

In order to verify that the suggested equivalent circuit shown in Figs. 1 and 2 is independent of frequency up to 1kc/s, taking into account the frequency dependence of α as discussed above, measurements were made using a wideband detector at 250c/s and 1kc/s on a group of transistors consisting of the two Brimar types mentioned above and two American types having $f_{c\alpha}$ in the region 5 to 10Mcs. The indication from these few measurements is that over this frequency range the resistive parameters are indepen-

TABLE 1

TRANSISTOR	CIRCUIT 1A			CIRCUIT 1B				CIRCUIT 2			
	r_e (MΩ)	C_c (pF)	Time Constant (10^{-6} sec)	r_{out} (KΩ)	C_{out} (pF)	Time Constant (10^{-6} sec)	Apparent α_{cb} (*)	α_{cb}	Phase of α_{cb}	$f_{c\alpha}$ (kc/s)	$f_{c\alpha}(1-\alpha)$ (kc/s)
TJ 1 ..	2·56	35	92	115	650	75	21	21	6°	330	15
TJ 3 ..	9·6	34	330	74	2900	217	129	104	15°	650	6

* Obtained from ratio of r_e/r_{out} assuming $r_{out} = r_e(1-\alpha)$

TABLE 2

TRANSISTOR	r_{out} (kΩ)	C_{out} (pF)	Time Constant (10^{-6} sec)
TJ1 ..	110	700	77
TJ3 ..	72	3200	230

dent of frequency to within less than 5 per cent except in the value of r_e for the Brimar TJ3 which shows a fall of 10 per cent with reduction of frequency. The margin in the case of C_c and $C_c/(1-\alpha)$ is also 10 per cent, but this is due to reduction in sharpness of reactive balance at the lower frequency. This is considered sufficient, but there is also a general tendency for r_e in the low frequency transistors to decrease with frequency and it seems likely that if measurements were made on a large number of such transistors then variations in r_e of greater than 10 per cent may be encountered.

Another point for comment is that if reference is made to the measurement procedure in Circuits 1a and 1b it will be seen that if the transistor equivalent circuit were exactly as shown then the balancing capacitor C_v would not require re-adjustment in the 2nd balance in either circuit. In practice this is not found to be the case and it is attributed to the fact that the inner end of capacitor C_c is connected to some point along the base resistance as shown in Fig. 9, the explanation being as follows.

If the balance conditions are calculated in terms of this transistor equivalent circuit then it is found that the conditions as given by equations (1) to (10) are not affected, provided that for r_b one substitutes $(r_{b1} + r_{b2})$, and also if the values of C_v for the 1st and 2nd balances in either circuit are C_v and C_v' then one obtains the additional conditions for the 2nd balances in each circuit as follows:

$$\textit{Circuit 1a} \quad r_{b2} = (C_v'/C_v) \cdot R_{v2} \quad \ldots\ldots\ldots \quad (11)$$

$$\textit{Circuit 1b} \quad r_{b1}' + r_e = (C_v'/C_v) \cdot R_{v2} \quad \ldots\ldots \quad (12)$$

where $r_{b1}' = r_{b1}(1-\alpha)$ and a correction to the value of $(1-\alpha)$ is required unless the frequency dependence of α may be neglected.

Hence, if the equivalent circuit of Fig. 9 is correct then r_{b1} and r_{b2} may be measured separately and their sum compared with the measured value of $(r_{b1} + r_{b2})$ given by equation (3).

Measurements made on the small group of transistors mentioned above show that good agreement is obtained between the sum of r_{b1} and r_{b2} and the measured value of r_b at 1kc/s in the case of the h.f. transistors, but there is poor agreement in the case of the l.f. transistors. Further, when the frequency is reduced to 250c/s, although errors are caused by reduction in sharpness of reactive balance there is a general reduction in the value of r_{b2} of at least 20 per cent and is as high as 50 per cent in the case of the Brimar TJ3. From this it may be concluded, therefore, that although the equivalent circuit of Fig. 9 is more correct than that shown in Fig. 5 there are still certain reactive elements missing which cause a variation with frequency of some of the parameters and this variation is greatest in the case of l.f transistors, but may be negligible in the case of h.f. transistors.

However, measurements of input and output impedances at higher frequencies suggest that the main reactive elements missing from Fig. 9, excluding the reactance associated with the internal generator, are shunt capacitances associated with r_{b1} and r_e and it is believed that the capacitance in shunt with r_{b1} is of the order 0·001μF to 0·01μF. The balance conditions based on such an equivalent circuit show that at low frequencies where the error in measurement of $(r_{b1} + r_{b2})$ is negligible the error in measurement of r_{b2} is independent of frequency and may be very large depending on the parameters of the transistor. It is clear, therefore, that a negligible variation with frequency in the measurement of r_{b2} does not necessarily imply freedom from error caused by neglect of reactive elements in the transistor equivalent circuit. And since r_{b1} usually appears to form the greater part of $(r_{b1} + r_{b2})$ and its value is subject to considerable error in calculation it follows that large errors of any kind in measurement of r_{b2} may not be detectable.

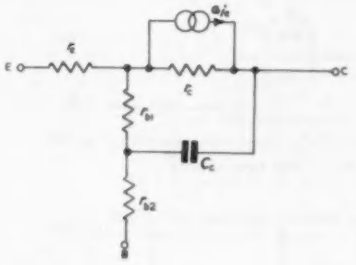

Fig. 9. Illustrating the need for re-adjustment of C_v

Hence the above equivalent circuit is regarded only as a partial explanation of the observed facts and the method is not considered to be generally reliable for measurement of r_{b1} and r_{b2}. However if calculations are confined to equation (1) to (10), excluding equations (4) and (5), it is concluded that the equivalent circuit parameters will be, for most transistors, substantially independent of frequency up to 1kc/s although increases in r_e of greater than 10 per cent for an increase in frequency from 250c/s to 1kc/s may occur in the case of certain low frequency transistors. If, using only equations (1) to (7), frequency dependent errors in r_e and $r_c(1-\alpha)$ are to be completely avoided then it would be necessary to reduce the measurement frequency to about 200c/s or less but this improvement would be obtained at the expense of reduced accuracy in output capacitance measurements.

Acknowledgment

The author is indebted to Messrs. Standard Telecommunication Laboratories Ltd for permission to publish this article and to Mr. T. H. Walker under whose supervision the work was carried out.

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The Reactance Valve at Audio Frequencies

By B. J. Alcock, B.Sc., Ph.D.

The reactance valve circuit is analysed to derive circuits producing an inductive impedance at audio frequencies with particular reference to obtaining a large Q factor.

THE reactance valve circuit consists basically of a feedback amplifier in which the feedback path has a transmission factor which introduces a phase shift of approximately 90°. The output impedance of the amplifier can be arranged to be predominantly reactive and either positive or negative. The magnitude of the impedance varies with the gain of the amplifier, and is sometimes used to vary the frequency of an *LC* oscillator. Another feature is that, using only physical capacitive reactances, an effective inductive reactance may be produced. Most of the available theory on reactance valve circuits contains numerous approximations, and its application is limited to radio frequencies. This article attempts to provide a more exact analysis so as to

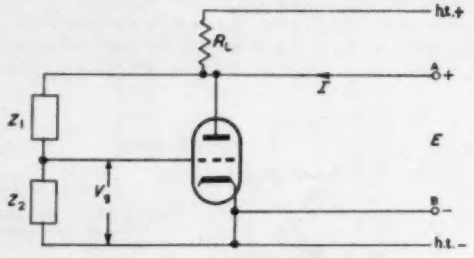

Fig. 1. The basic circuit

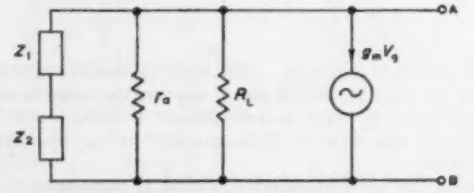

Fig. 2. The equivalent circuit for Fig. 1

deduce the effects of the circuit values upon the effective Q factor of the reactive impedance produced. Calculations are made of the optimum values and circuit arrangements, and the highest Q factors reasonably attainable. The analysis has been carried out for a frequency of 1kc/s.

Analysis of the Basic Circuit

The incremental impedance Z_{AB} seen between the terminals A and B can be found using the equivalent circuit of Fig. 2, where $g_m V_g$ is a constant current generator, from which the ratio E/I for incremental changes and assumed quasi-linear conditions can be calculated as follows.

Let

$$\beta = \frac{Z_2}{Z_1 + Z_2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Then from Fig. 1

$$V_g = \beta E \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Thus the equivalent circuit for the impedance Z_{AB} is as shown in Fig. 3.

When Z_1 is a resistance R and Z_2 is a capacitance C then

$$\beta = \frac{1}{1 + j\omega CR}$$

Thus

$$1/\beta g_m = (1/g_m) + j\omega(CR/g_m) \quad \ldots\ldots\ldots \quad (3)$$

One may now write the circuit for impedance Z_{AB} as shown in Fig. 4.

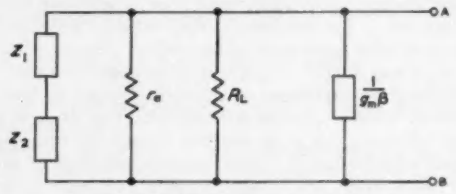

Fig. 3. The output impedance Z_{AB}

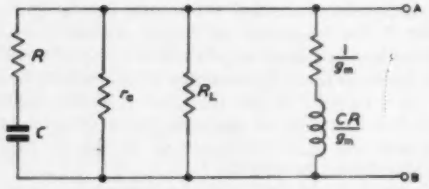

Fig. 4. The impedance Z_{AB} when an RC feedback network is used

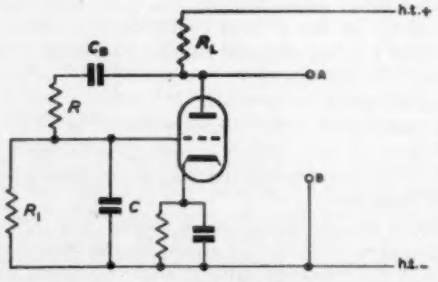

Fig. 5. A practical circuit

In order to arrange for the correct d.c. operation of the valve the practical circuit will take the form shown in Fig. 5 in which C_B is a large blocking capacitor, and R_1 is the necessary grid to earth resistor.

In considering the optimum values for the circuit elements so as to give an inductive impedance with the maximum Q, the following points may be noted.

R_L must be as large as possible, preferably at least as large as r_a which must also be large. Also as the inductance and series resistance are shunted by resistances then for the maximum possible Q, g_m must be as large as possible. The conditions for r_a and g_m can be best satisfied by a high

slope pentode, and in the experimental work an SP61 was used.

A convenient method of making R_L large, without having to resort to very large values of h.t. is to use a triode with current feedback as the anode load of the reactance valve. The incremental impedance Z_{XY} seen between the points X and Y in Fig. 6 is given by

$$Z_{XY} = r_a + (\mu + 1)R_B \quad \ldots\ldots\ldots\ldots (4)$$

assuming that $R_g \gg (1/j\omega C_g)$ and that the cathode bias resistor R_X is small compared to the cathode load resistor R_B.

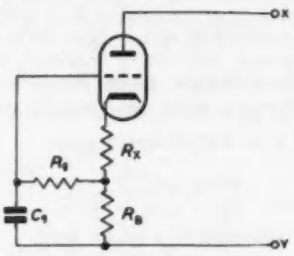

Fig. 6. A load network with a high incremental impedance

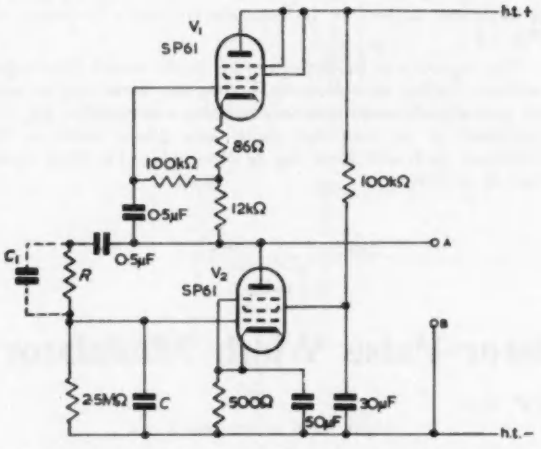

Fig. 7. A practical circuit incorporating a high impedance load network

A suitable circuit is shown in Fig. 7 using SP61's for both valves, the upper one being strapped as a triode. Using the values shown the a.c. impedance of the triode with current feedback is about 0·7MΩ, and this is approximately equal to r_a of the pentode.

In this form, however, the Q of the inductive impedance is limited by several factors. Firstly R and C appear in series across the terminals AB, and if R is made large the stray capacitances across it affect the phase shift and lower the Q. Secondly as R and thus $1/j\omega C$ must be kept large the grid resistor also reduces the maximum Q obtainable. The expression for the Q for this circuit is given below, which shows the effect of R_1 and the stray capacitance C_1 across R, assuming the blocking capacitor C_B is large enough to be neglected.

$$Q = \frac{1}{(1/\omega CR) + (1/\omega CR_1) + \omega C_1 R + (\omega CR/g_m R_a) + (\omega C/g_m)} \quad \ldots\ldots\ldots\ldots (5)$$

where R_a is the anode impedance of V_2 in parallel with its anode load impedance. The optimum values of R and C are obtained by partially differentiating equation (5) with respect to C and equating to zero, then repeating this with respect to R, and solving the two resulting equations for C and R. The final equation in R is unfortunately of the fifth order and its solution can be laborious, especially if complex roots are present. For the circuit of Fig. 7 C_1 was approximately 7pF and the optimum values of R and C calculated for a frequency of 1kc/s using the above method were 270kΩ and 0·03μF respectively. This gives a calculated value for Q of 14 and the measured value was 13·2.

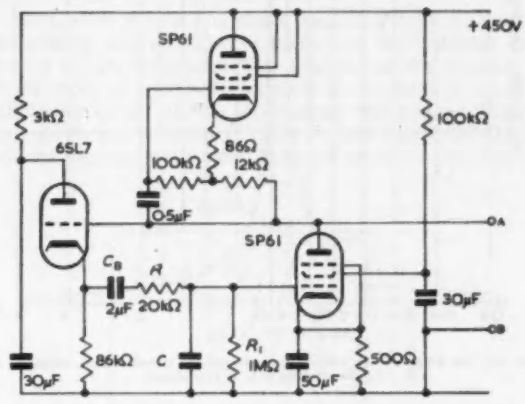

Fig. 8. An improved circuit with cathode-follower buffering

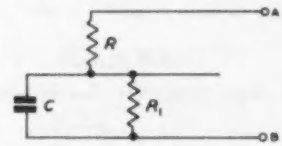

Fig. 9. The equivalent feedback network of Fig. 8

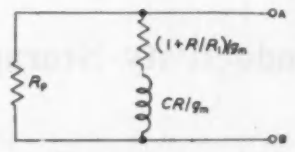

Fig. 10. The impedance Z_{AB} for Fig. 8

An Improved Circuit

Fig. 8 shows a circuit with a cathode-follower in the feedback path. This enables R to be reduced in value so that C_1 may be neglected. Also R and C in series do not appear across AB, and the direct coupled cathode-follower input impedance is high enough to be ignored.

The values of the feedback network must now be chosen so as not to adversely affect the cathode-follower gain, and also to take into account the criteria mentioned above. The loss in the cathode-follower may be taken into account in the calculations by multiplying the g_m of the reactance valve by the gain of the cathode-follower.

Using the circuit of Fig. 8 in which R has been made as small as possible, and R_1 as large as possible, and C_B large

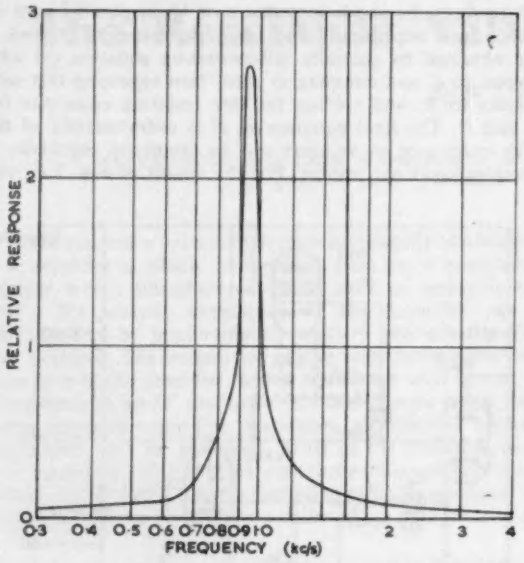

Fig. 11. The graph of the relative response of the tuned circuit consisting of Z_{AB} in parallel with a capacitance

enough to be neglected, the feedback network is as shown in Fig. 9.

Now

$$\beta = \frac{1}{j\omega CR + R/R_1 + 1} \quad \ldots\ldots\ldots\ldots (6)$$

Thus the equivalent circuit for Z_{AB} is now as shown in Fig. 10.

Now Q_0 for the network excluding R_a is given by

$$Q_0 = \frac{\omega CR}{1 + R/R_1}$$

And Q for the whole network is therefore

$$Q = \frac{1}{1/\omega CR + 1/\omega CR_1 + \omega CR/g_m R_a} \quad \ldots\ldots (7)$$

Considering only the denominator of equation (7).

$$d(1/Q)/dC = -(1/\omega C^2) - (1/\omega C^2 R_1) + (R/g_m R_a)$$

Equating to zero and taking the value to give a minimum for $1/Q$.

$$C = \sqrt{\left(\frac{R + R_1}{R_1} g_m R_a\right)}$$

Substituting the numerical values. $R_1 = 10^6\Omega$,

$R = 20 \times 10^3\Omega$, $g_m = 9{\cdot}3 \times 10^{-3} \times 0{\cdot}94$mA/V,

$\omega = 2\pi \times 10^3$, $C = 0{\cdot}42\mu$F which gives

$Q = 26{\cdot}0$

and $L = 1{\cdot}05$H

The values measured on a circuit were

$Q = 24{\cdot}5$

and $L = 0{\cdot}98$H.

A response curve of the tuned circuit formed by placing a capacitor across AB to resonate at 1kc/s is shown in Fig. 11.

This appears to be the optimum performance obtainable without further complication, and in this form can be used to provide effective inductances with a reasonable Q. The inclusion of an amplifier (with zero phase shift) in the feedback path will raise the Q obtainable, the limit being one of stability.

A Conductivity Storage Transistor Pulse Width Modulator

By J. C. Price*, B.Sc.

Transistors of both point-contact and junction types exhibit in certain pulse applications, prolonged conduction generally ascribed to 'hole storage'. This can be controlled in a circuit to provide a simple means of pulse width modulation for time division multiplex. The technique is described for use with selected point-contact transistors.

A VERY important field of application for transistors is in low power pulse circuits such as are used in digital computers and time division multiplex systems. The small physical size and modest power requirements of transistors make elaborate electronic systems practicable without the apparatus becoming very bulky. Since there appears to be nothing in a transistor to wear out[1] it should be possible ultimately to achieve a very high standard of reliability with these devices. These considerations point to the importance of transistor pulse circuits particularly those requiring a minimum of associated components.

The transistor pulse width modulator described here had its origin in work carried out to achieve improved reliability and independence of individual transistors in pulse circuits. In a particular pulse circuit it was found that, with the samples of point contact transistors then being produced, a wider pulse occurred than was predicted by simple theory. A way was available to prevent the unwanted effect in the particular application, and further, the possibility was considered of exploiting the effect to some useful purpose. From this emerged the pulse width modulator described here.

* *Standard Telecommunication Laboratories Ltd.*

Mechanisms Influencing Turn-Off Time in Transistor Pulse Circuits

Consider a transistor circuit fully turned on. Making a direct appeal to elementary physical theory of transistors, it would appear that the collector current might be limited by two possible mechanisms:

(1) Under the operating conditions at that point, the emitter is unable to supply sufficient holes.

(1) The emitter is emitting holes freely, but the collector potential is insufficient to enable these to be collected.

Thus one might expect collector current pulses of equal duration with the emitter current to occur in condition (1), and widened pulses in the case of (2) due to the excess of holes injected during the emitter pulse but not used.

A tentative correlation of this with the load line diagram of the pulse circuit is as follows:

Fig. 1 is a sketch showing the load line of some pulse generator circuit on the output characteristics of a point contact transistor. The load line is shown straight for illustration. In practice it may have a rather complicated form due to the effect of feedback or non-linear loads. In the case of a pulse generator of the type shown in Fig. 2, if the means of feedback is an open-circuited delay line, initially the load approximates to the characteristic imped-

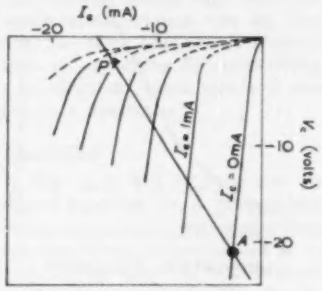

Fig. 1. Load line of pulse generator where P falls in region (2)

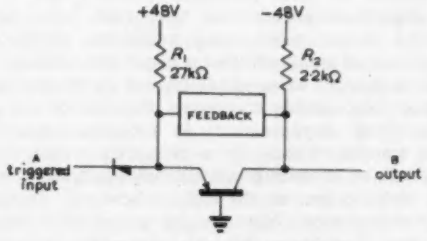

Fig. 2. Basic type of trigger circuit

ance of the line in shunt with R_2. The transistor characteristics are shown in two parts by whole and broken lines. It may be supposed that the region of full line presentation corresponds to condition (1) and that the region of broken line presentation corresponds to condition (2).

Point A represents the 'off' state of the pulse generator and point P the 'on' state. Where point P occurs will be a function of emitter current and the current gain of the transistor for given circuit parameters. Fig. 1 illustrates the case where P falls in region (2). Fig. 3 shows the case where P occurs in region (1). Fig. 4 shows the case where the load line changes direction at Q and the 'on' position occurs at R. Such an effect could be obtained by a catching diode. This was suggested by E. H. Cooke Yarborough[2] for preventing widened pulses. The larger collector potential in the 'on' state secured in this way assists the attraction of holes to the collector; consequently the collector current is somewhat greater and fewer holes are stored in the body of the transistor.

From the above remarks it will be seen that if a circuit is devised in which a modulating signal controls the extent to which a pulse generator in the 'on' condition is driven into condition (2) width modulation of the pulse will occur.

Theory of Operation

A basic type of transistor trigger circuit[3] is shown in Fig. 2. The transistor is a point contact type. Typical biasing conditions are indicated and the feedback from collector to emitter may take the form of a capacitor, series tuned circuit, or open-circuit delay line.

With point A held at a small negative potential to earth, the emitter will produce no holes and the collector will present a high impedance. The potential of the collector is of the order of -40V. If the potential applied to A is raised sufficiently to cut off the input diode, the current flowing through R_1 will be directed to the emitter and holes will be injected into the germanium. Some of these are attracted to

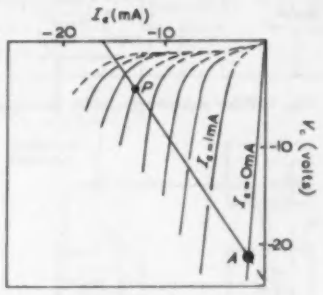

Fig. 3. P falling in region (1)

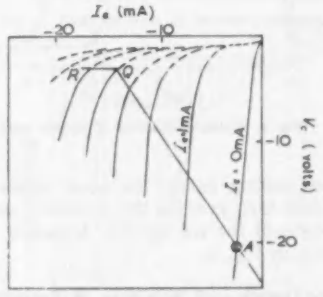

Fig. 4. Load line changing direction of Q

the collector causing increased collector current. This will raise the potential of the collector. With a feedback circuit such as any of the types mentioned, the action will be cumulative while the feedback continues, and the pulse generator is driven to the 'on' position. After a period of time which is a function of the feedback circuit the current fed back to the emitter ceases preventing further emission of holes. In the absence of appreciable hole storage and transit time effects, the collector current and hence collector potential falls, and the pulse generator reverts to the 'off' position.

The description so far is a brief sketch of the action of a normal transistor pulse generator. If, however, during the emitter pulse, holes are stored in the germanium, the collector current will continue at a high level until these holes are used up as considered above. Such conditions of hole storage are obtained with selected transistors of high current gain and by use of a fairly high collector resistance. A diode is used to control the collector potential, and hence hole storage, during pulses giving direct width modulation of the normal generator output[4].

The circuit of a complete pulse width modulator is shown in Fig. 5. X_1 is a selected point contact transistor. The pulse generator is triggered by a positive-going pulse to the emitter via MR_1. In the conducting conditions the collector potential is clamped by MR_2 connected to the modulating audio source. A load of 680Ω is used shunted by a 0·04μF

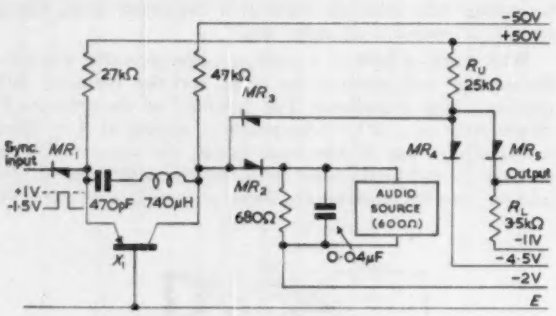

Fig. 5. Pulse generator for width modulator

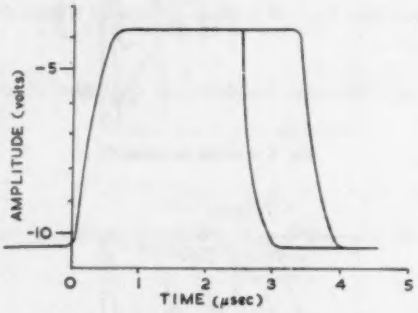

Fig. 6. Width modulation of output pulse

capacitor for storing energy between pulses. The diodes MR_3, MR_4 and MR_5 provide the necessary clipping of unwanted portions of the waveforms. A typical output waveform is shown in Fig. 6.

Performance Details and Selection of Transistors

Fig. 7 is a curve showing the relation between delay of the back edge of the pulse, measured from an arbitrary origin and the controlling voltage on diode MR_2. It will be seen that a linear relation holds over the region, approximately $-2 \pm 0{\cdot}75$V. The only limitations on modulating frequency are those inherent in the recovery time of the pulse generator. Since the pulse generator used in the tests was operated at about 20kc/s there is clearly no restriction on the audio range that can be modulated in this way.

An advantage of this method of p.w.m. is that it produces a width modulated pulse of reasonably high power. Hence for example p.t.m. (pulse time modulation) can be readily obtained using a differentiating transformer.

It is found that most production point contact transistors will give some storage effect of the type required, e.g. Bell A1698 and Standard 3X/100, but the effect is generally too small to be useful. This is particularly so since manufacturers of point contact transistors for pulse circuits now generally aim to reduce hole storage as much as possible.

For practical modulation the large storage effect obtained with a few selected samples is required. Suitable transistors were most plentiful in a batch made with 4 to 6Ω-cm germanium with antimony only as the impurity.

In the course of selecting transistors two effects have been noted which tend to be associated with this storage effect. The first of these is high initial values of current gain α. It is required that the mean α for $0 < I_e < 0{\cdot}5$mA and $V_c = -20$V must exceed five, where I_e = emitter current and V_c = collector voltage. The other associated effect is a falling off in rectification efficiency at a comparatively low frequency, approximately 50kc/s, using the collector and base as a diode.

The basic cause underlying these three related effects is not completely understood. Attempts have been made to interpret them in terms of various physical theories of the point contact transistor which have been advanced publicly[5,6] and in private discussion, but no single theory has been decisively established.

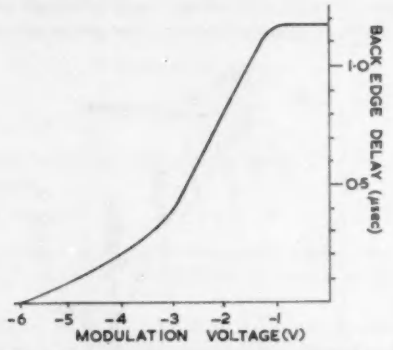

Fig. 7. Delay back edge of pulse as a function of modulation potential

Conclusions

The degree of selection of transistors now necessary makes the present pulse width modulator purely experimental. It was first thought that it might be possible to obtain suitable storage by some minor change in the manufacture of present point contact transistors, but this has not proved so easy. With improvements in frequency response of junction transistors these have gained in favour for pulse circuits both on account of their greater gain and reliability. It may well be that in the future these will be used for conductivity storage. Nor are the possibilities limited to modulation of collector potential, for other arrangements in which storage is controlled by modulating potentials, currents or impedances are possible.

Moreover, if effective control of conductivity storage in semi-conductor devices can be achieved, a much wider use of semi-conductors in multiplexing and automatic switching can be envisaged in which conductivity storage in a dice of germanium replaces energy storage in relatively bulky capacitors and inductors.

Acknowledgments

The author is indebted to Mr. K. W. Cattermole for the point contact pulse generator employed in the modulator circuit described, and thanks Standard Telecommunication Laboratories Ltd, for permission to publish this article.

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A FUNCTION GENERATOR

By N. Hambley*, B.Sc.

When it is desired to control an operation according to a complex variable function, it is convenient to obtain control directly from a graphical function. The apparatus described here uses a photocell and cathode-ray tube to convert graphical data into a suitable electrical form. The conversion accuracy is better than one per cent.

IN order to study the behaviour of metal structures and specimens at various temperatures, heating equipment is required and it is necessary that the temperature is accurately controlled. During the investigations it may be necessary to change the desired rate of temperature rise between wide limits. The heating equipment is required to follow different functions for the various specimens, and the curves may be complex. To cover all possibilities an automatic graph reading device was considered necessary, so that the temperature control can be derived quickly from a graphical function. This article describes the design and construction of apparatus for converting a graphical function into an electrical form which is used to control the temperature of a specimen.

Principle of Operation

Referring to Fig. 1, it will be seen that the conversion from a graphical function to a proportional voltage is achieved by means of a closed loop feedback system involving the cathode-ray tube, photocell and Y amplifier. The vertical position of the spot on the cathode-ray tube is controlled by the Y amplifier. With the feedback loop closed, as shown, the Y amplifier is controlled by the photocell which in turn, is actuated by the cathode-ray tube spot. If the graphical function, with its upper portion blacked out, is interposed between photocell and cathode-ray tube, the spot will adjust itself on to the edge of the black portion. The sense of the feedback is arranged such that any deviation from the common black-white boundary causes the Y amplifier to exert a greater pull back again. This ensures that the spot remains on the black-white boundary all the time when the feedback loop is closed. The output voltage function is derived from the Y amplifier, which gives a voltage proportional to the vertical position of the spot. The cathode-follower and level control reduce the function into the necessary form for operating the temperature controlling system.

It is, of course, essential that the photocell receives light only from the cathode-ray tube spot. Accordingly the cathode-ray tube and photocell are housed in a light proof enclosure. The horizontal spot position is controlled by the time-base. The latter can be set to scan the graph in any integral number of minutes from one to thirty inclusive. Stabilized power supplies are necessary, to keep the conversion within the specified accuracy of one per cent.

In order to exclude external light, the photocell and cathode-ray tube are housed in a light proof enclosure. This assembly is painted with a matt black finish to minimize the effects of reflection. The graphical function is carried on a frame which is mounted between the photocell and the face of the cathode-ray tube. The front portion of the light proof enclosure is hinged to allow access for interposing the function between the tube and photocell. A typical graphical function is shown in Fig. 2. Temperature is the ordinate and the upper portion of the curve is blacked out. This may be done by cutting the curves from black card, or by blacking out one portion of a photographic plate.

* *A. V. Roe & Co. Ltd.*

The cathode-ray tube, (type DB 13-2) has a post deflexion accelerator which enables a fine spot to be obtained. The electrode potentials are tapped from a resistor chain connected between +2kV and −2kV, so that the focusing assembly voltage is approximately +250V. This is necessary to prevent defocusing due to a difference of voltage between the focus anodes and the mean deflector plate voltages. Since these voltages are directly coupled to the X and Y amplifiers they necessarily have a mean voltage of +250V. Symmetrical push-pull deflexion systems are used on both X and Y amplifiers. A Mumetal screen is placed round the tube to minimize the effect of stray magnetic fields.

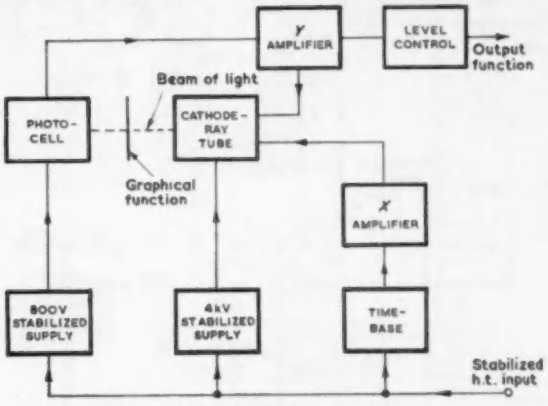

Fig. 1. Block diagram of function generator

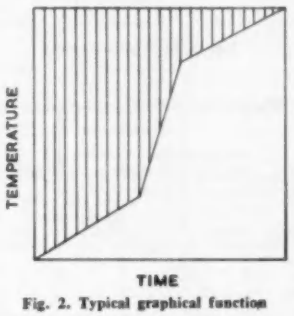

Fig. 2. Typical graphical function

The photocell is a photo-multiplier, type 27M2, and requires a potential chain of 800V to operate with a current gain of 250 000. The current caused by full view of the cathode-ray tube spot is about 1mA and the dark current is less than 1μA. This current variation demands a high degree of stabilization in the 800V power supply. As the photo-multiplier is most sensitive to blue light, this colour is chosen for the cathode-ray tube face.

Stabilized 800V Supply

The anode of the photo-multiplier is directly coupled to the input of the Y amplifier and so the positive end of the

800V is at approximately earth potential. A radio frequency oscillator unit[1] is chosen as the source of e.h.t. voltage because of its inherent advantages over the conventional mains method. There is a reduction in size and weight of the transformer and capacitors. In addition, an r.f. supply is non-lethal and an accidental overload quenches the oscillation.

Fig. 3 shows an audio pentode is used as oscillator. Transformer coupling is arranged between anode and grid to provide the oscillation. The e.h.t. and rectifier heater

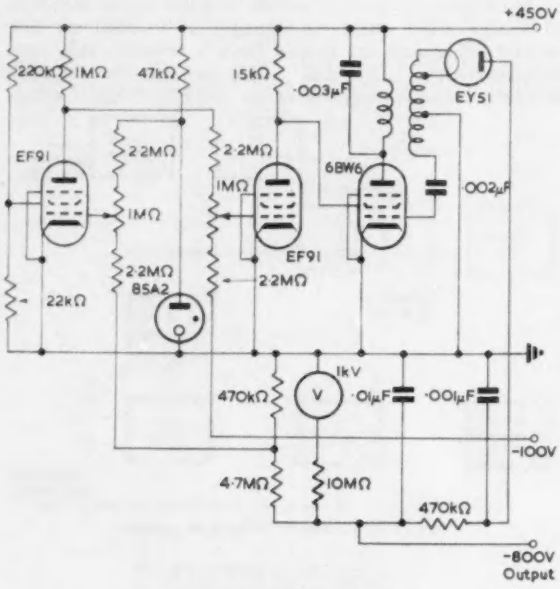

Fig. 3. 800V power supply

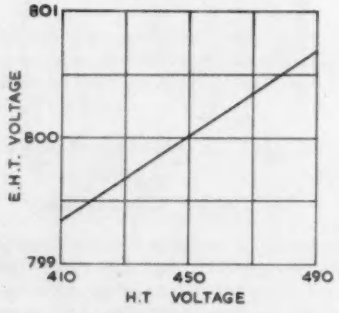

Fig. 4. E.H.T. regulation

supply are derived from coils wound on the same transformer. The e.h.t. transformer was originally wound on an air-cored former, but later a ferromagnetic core was used and found to give better regulation and simpler construction. The material used is Mullard FX1031 ferroxcube.

Stabilization[2] is achieved by controlling the screen grid voltage of the oscillator valve. A portion of the e.h.t. is fed back, after amplification, on to the oscillator screen grid. It is necessary to use a two valve system in order that the feedback is in the correct sense. The amplifier is d.c. coupled, the first stage being operated under 'starvation' conditions. The second stage acts as an invertor with comparatively low gain. The overall gain of the amplifier is about 5 000 and the losses within the loop amount to about 100. This indicates a stabilization ratio of 50 to 1. The regulation curves are shown in Fig. 4. The level of ripple is 0·05V, at 10kc/s. The output voltage is monitored on a moving-coil meter with a 100μA movement and a 10MΩ series resistance. The h.t. power is drawn from a stabilized power supply giving +450V and −100V.

The 4kV Supply

The cathode-ray tube e.h.t. is similar in principle to the 800V supply. One difference is, however, that the 4kV potential chain is earthed at its centre point so that the focus anode voltages may be at about +250V. This makes the final anode at +2kV and the grid at −2kV. Also it is found to be necessary to use two audio pentodes for the oscillator, because the tube takes a beam current of 2mA at full brilliance. The stabilization of this power supply is achieved by a two-stage d.c. amplifier. The percentage regulation is similar to that shown in Fig. 4. One of these units has been in continuous use for a period of over 6 months, and during this time has not required any adjustment. H.T. again comes from a stabilized power pack.

X Amplifier and Y Amplifier

The amplifiers are shown in Fig. 5. A twin triode is used as a long-tailed pair to provide push-pull deflexion voltages to the X plates. The anodes are connected to the X plates. One of the grids is connected to the X shift control and the other grid is connected to the time-base voltage generator. The Y amplifier has a similar arrangement, except that the second grid is connected to the photo-multiplier anode in order to close the feedback loop.

Feedback Loop

To follow the action of the feedback loop it is convenient to start at the cathode-ray tube spot. When the spot is partially hidden behind the blacked out portion of the curve, the photo-multiplier receives a certain amount of light, which causes a potential drop across its anode resistor. This voltage is directly coupled to the Y amplifier grid, which controls the vertical position of the spot. This adjusts itself until the portion visible to the photocell is sufficient to balance its vertical position. It will be seen, therefore, that as the spot follows the function more of the spot is visible at one end of the curve than the other. This effect is shown diagrammatically in Fig. 6, where the spot is shown in three positions. The spot size is magnified over 30 times for the purpose of illustration. The dotted line shows the deviation from the function, which is an inherent feature of the d.c. feedback loop. In practice the spot has a very small diameter, and the variation of the visible amount of the spot is about one-tenth of its full size. This limits the maximum deviation to one-tenth of 1 per cent of full scale.

Time-Base

A slightly modified Miller rundown circuit is used to provide the necessary linear voltage change for applying to the X amplifier, shown in Fig. 5. The spot is thus made to cross the cathode-ray tube face at a steady speed. The time taken is selected by varying the resistor in the Miller *RC* network. This can be set to give full scan of a function in any integral number of minutes between one and thirty inclusive. The time-base is started by applying a positive step function to the suppressor grid of the Miller valve. The linearity of the time-base is better than one-tenth of one per cent. The h.t. power for the time-base is derived from a +450V stabilized line and a −100V stabilized line.

Output and Level Control

The output function is in the form of a voltage, the

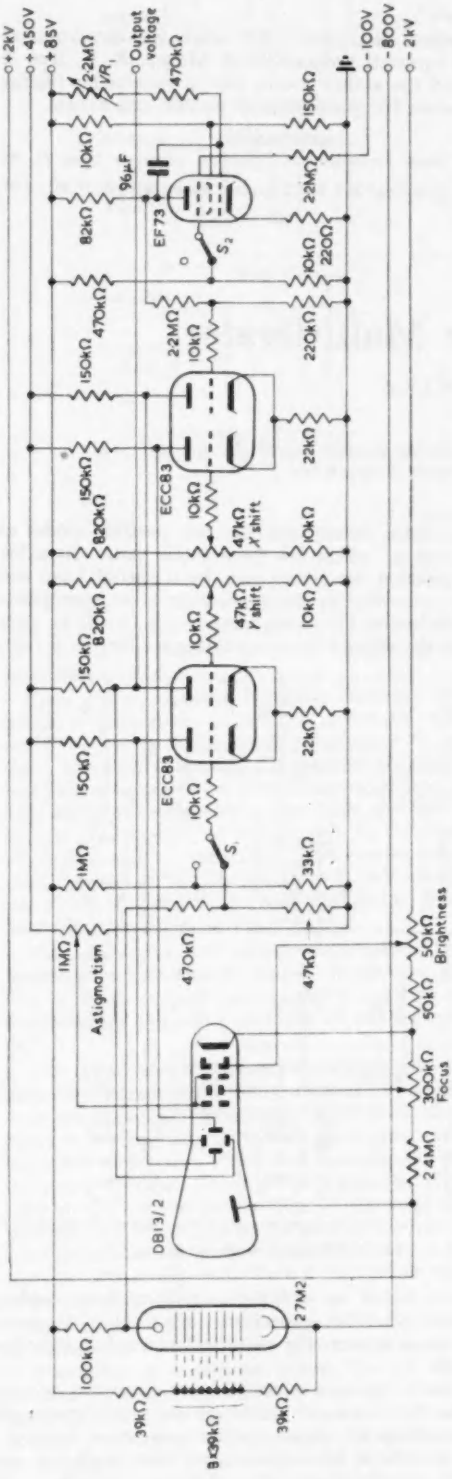

Fig. 5. Cathode-ray tube, amplifiers and time-base circuits

Switch S_1 is the feedback control, and switch S_2 is the time-base on/off control. VR_1 is the time-base duration control which is in the form of a thirty way Winkler switch in the present equipment.

amplitude of which is proportional to the ordinate of the graphical function at any time. The voltage function is derived from the Y plates of the cathode-ray tube and is attenuated to give a range of zero to 8V, which corresponds to the range of the ordinate on the graph. The function is fed through a cathode-follower to the output terminals, see Fig. 7. Two safety circuits are incorporated which open-circuit the output in the event of the voltage function leaving the range zero to 8V. The safety circuits

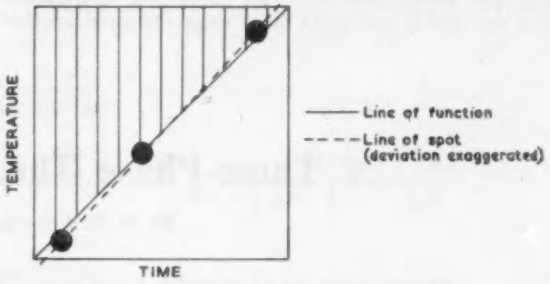

Fig. 6. Showing deviation of spot

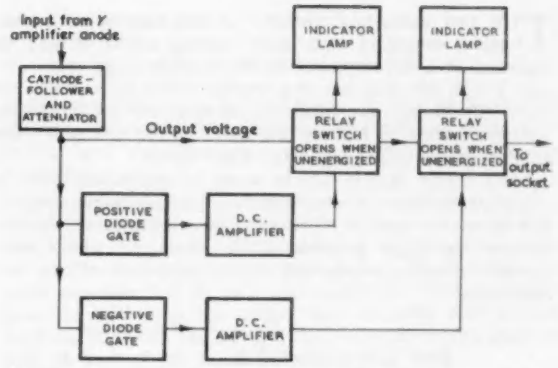

Fig. 7. Level control system

When the output voltage reaches +8V the positive diode gate opens, after which 0·01V applied to the d.c amplifier is sufficient to make the d.c. amplifier open the first relay switch. This open-circuits the output, and the switch remains open until the voltage returns to below +8V. The negative diode gate operates similarly if the output voltage becomes negative. The indicator lamps are arranged to show when their associated relays are energized.

are fail-safe devices, and one or the other of the circuits will operate when any valve or component failure occurs. In conjunction with the safety circuits, warning lamps are arranged to indicate the type of fault.

Constructional Details

The equipment consists of two units, each of which is mounted on a standard Post Office rack panel. One unit holds the light proof enclosure and the other unit contains the amplifiers, power packs, time-base and the controls.

Operating Procedure and Characteristics

Since the equipment is designed for use by unskilled personnel, the number of controls is reduced to a minimum. When the power packs have been switched on there are only four controls which are used to generate a function. Two of these controls are used to set the abscissa and ordinate of the function to correspond with units chosen for temperature and time on the graph. Of the remaining two controls, one is used to close the feedback loop and

the other is used to start the time-base, which begins the generation of the function. At the end of the time period selected by setting the abscissa, the function switches off automatically. The output voltage function is monitored by a meter on the front panel.

Conclusions

The equipment follows a curve within an error of one per cent. At present it is being used to convert graphical data into an electrical form for controlling temperature. It is felt that it may have many more industrial applications as an alternative to the more expensive methods of control by digital computation.

Acknowledgments

The apparatus described in this article was developed as part of the research programme of Messrs. A. V. Roe & Co., Ltd, and the author would like to express his thanks to the Directors for permission to publish this article.

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2. Lowe, A. E. A Stabilized R. F. E.H.T. Supply. *Electronic Engng, 27*, 85, (1955).

A Three-Phase Three-Valve Multivibrator

By W. F. Lovering*, M.Sc., A.M.I.E.E.

The two valve multivibrator is a well-known source of rectangular voltage waves. In this article a three-valve, three-phase version of this circuit is described.

THE two valve multivibrator is well known as a convenient source of rectangular voltage waves; it may be regarded as a development of the bistable Kipp relay circuit. The Kipp relay has two possible stable states with one valve cut-off and the other conducting; the multivibrator changes from one state to the other as the charge on the appropriate coupling capacitor leaks away.

Multi-stable circuits may be made by connecting three or more valves with d.c. couplings; each anode being coupled to every other grid. A three valve circuit connected in this fashion has eight possible stable states, of which two, namely all valves conducting and all valves cut-off, are unimportant.

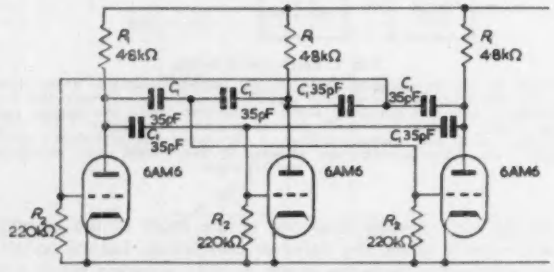

Fig. 1. Circuit of three-phase multivibrator

With screens at +250V; repetition frequency ≃13kc/s. The grid time-constant is $2C_1R_2$

If three valves are so coupled and a small negative grid bias voltage is applied all three valves conduct. If the negative grid voltage is gradually increased a state is reached at which one valve ceases to conduct. The anode voltage of this valve is then high which causes the other two grids to be driven positive so that grid current flows. A voltage pulse applied to the grids causes the non-conducting valve to conduct once more while one of the other valves cuts off. The circuit in this condition has three stable states with one valve cut off and the others conducting. If the negative grid bias voltage is increased further another condition is reached in which the circuit has three stable states but with one valve conducting and the others cut off.

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The three valve circuit thus has two possible modes of operation each of which has three stable states. In either mode of operation the circuit may be triggered from one stable state to another by the application of an appropriate pulse to all three grids or anodes. If the circuit is quite symmetrical the states will succeed one another in a random fashion but if an additional unidirectional coupling is introduced by small capacitors connected in sequence a_1 to g_2, a_2 to g_3, a_3 to g_1, the states will succeed one another in this order.

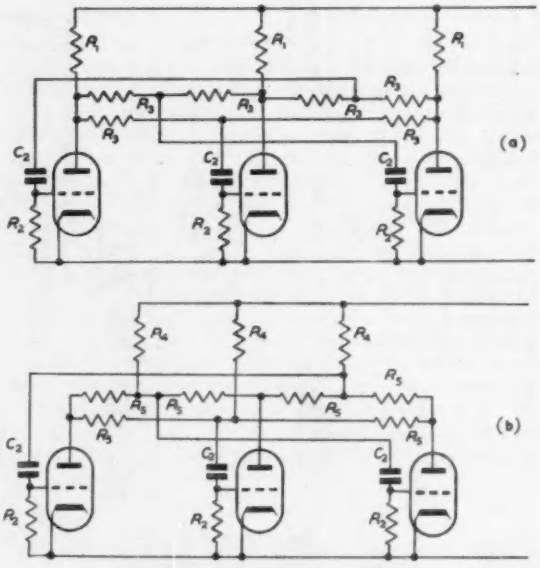

Fig. 2. Alternative circuit connexions

If the three valves are coupled by capacitances only (Fig. 1) the circuit acts as a three-phase multivibrator and generates rectangular anode voltage waveforms having a cycle of two thirds low voltage, one third high; or two thirds high, one third low, depending upon which of the two possible modes occurs.

Alternative connexions are shown in Fig. 2. The opera-

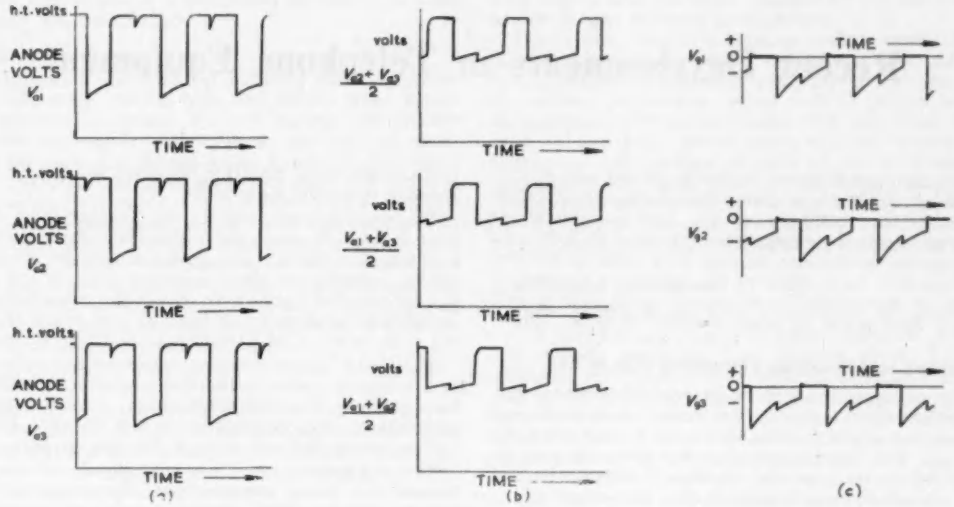

Fig. 3. Voltage waveforms

(a) Anode voltages
(b) Voltages mid-way in potential between anodes
(c) Grid voltages

tion of all three circuits is much the same but the circuit of Fig. 2(a) is simplest to describe. The two-off, one-on mode is assumed.

Each grid is supplied through a capacitor from a point which is midway in potential between the anodes of the other two valves. If the anode potential of V_1 remains constant, a rise in the anode potential of V_2 causes a rise of half this amount to be communicated to the grid of V_3. The anode potential of V_3 then falls and half this fall is applied to the grid of V_2. V_2 and V_3 therefore act as a multivibrator and 'turn over'. The anode potential of V_2 rises and that of V_3 falls and there is little change in potential of the mid-point. The grid potential of V_1 is therefore unchanged, as is its anode potential.

The anode and grid voltage waveforms of an oscillator working in the two-off, one-on mode are illustrated in Fig. 3. Each pair of valves acts in turn as a two-valve multivibrator and one is switched off and the other switched on.

The order of conduction, V_1, V_2, V_3 or V_1, V_3, V_2 is determined originally by any asymmetry in the circuit but once switching has commenced in a particular order, this order is maintained. Turn-over takes place when the grid capacitor of a valve which has been cut-off discharges to the point at which anode current restarts. The grid capacitor which has the greater time to discharge is, of course, that which is connected to the grid of the valve which has been cut off for the greater time. This valve is therefore the next to start conducting, when it turns over with the valve which has been conducting.

Oscillation in the 'two-on, one-off' mode is possible but is difficult to initiate. If the grid resistors are returned to a potentiometer connected across the h.t. supply and a positive bias applied while the circuit is oscillating it is possible to initiate this mode. However, if the h.t. supply is then switched off and restored, the oscillation does not recommence until the potentiometer is returned to the zero bias position. Oscillation then restarts in the two-off, one-on mode.

The two-on, one-off mode provides positive anode pulses lasting one third of a cycle. This is the type of waveform required for operating a three valve gate circuit using suppressor grid switching; each valve is switched on for one third of a cycle.

The two-off, one-on mode is more economical of h.t. power and provides positive anode voltage pulses of two-thirds of a cycle in duration. However, the circuit may also be used to supply positive voltage pulses of one-third of a cycle duration but of half the amplitude. This is simply achieved by taking the output from a point mid way in potential between the anodes; the potential at the point is half the sum of the anode potentials (Fig. 3(b)).

When a valve is switched off, its anode potential rises rapidly to the h.t. potential and stays constant at this value until the valve once more conducts. While the valve is conducting its anode potential changes slightly as the grid capacitor charge current changes. The positive half-wave is a close approximation to a rectangle but the negative half-wave is not.

The rise and fall times of the positive pulse are determined by the anode load resistance and the stray valve capacitances. Using miniature r.f. pentodes and anode loads of 5kΩ a rise-time of about 0·5μsec is obtained and a recurrence frequency of 50kc/s (positive pulse duration 6·6μsec) is possible with a good switching waveform.

For switching purposes a positive pulse is applied to a gating valve which is normally biased beyond cut-off; for this purpose only the positive waveform is important.

It has been found that four or more valves may be used in similar circuits to produce polyphase multivibrators but the circuits required are so complicated that their utility is doubtful; a four valve circuit for example requires twelve coupling resistors or capacitors to couple each anode to every other grid. The three valve multivibrator was developed to provide a switching waveform suitable for operating a three channel cathode-ray tube beam switch which could be used for the simultaneous examination of phenomena in each phase of a three-phase circuit. For this purpose the three-phase multivibrator was found to be simple and effective.

Recent Developments in Telephone Equipment

Research and development is being carried out continually by the Post Office, at their research station at Dollis Hill, and by the members of the telecommunications industry who supply the equipments into ways in which the public telephone service can be improved both technically and economically. As a result of this activity a number of new pieces of equipment have recently gone into service and a brief description of some of these is given below.

Group Routing and Charging Equipment (GRACE)

The lower charges for telephone calls which were recently introduced flow from a new system under which exchanges will be grouped and all exchanges in a Group have the same charges. The simplified system will pave the way for automation of the trunk service which will follow later and effect big operational and administrative economies.

For trunk dialling by subscribers, a system of national numbers will be required.

Post Office engineers have devised new equipment to handle most of the automatic operations involved in this innovation, and it is known as GRACE—Group Routing And Charging Equipment. It will interpret numbers dialled, route the call to the exchange required, dial the numbers wanted—often over hundreds of miles—and control the charging of the calls.

General Description

The Group Routing and Charging equipment performs automatically the functions which the trunk operator now does manually in setting up a call. It notes the number dialled by the caller and decides the correct route and charge rate. It then selects a route to the required exchange, and when the called subscriber answers it records the charge on the callers exchange meter.

The equipment has three main parts, Call Chargers, Registers and Translators, the number of these varying with the number of calls to be dealt with.

To make an automatic trunk call the caller dials the national number of the person to whom he wishes to speak. The first digit of all national numbers is 'O' and receipt of this digit by the exchange equipment causes the call to be connected to a Call Charger.

The Call Charger associates itself with a Register and the remaining digits of the number are received and stored in the Register which forms a memory for this information during setting up of the call. The first 1, 2 or 3 digits received by the Register identify the distant group. It is the function of the Translator to inspect these digits and deduce from them the route and charge rate for the call. The Translator is the brain of the system and incorporates a permanent memory giving details of the routes and charge rates for calls from the originating exchange to all other groups in the country.

The digits stored in the Register are referred to the Translator which examines them, identifies the exchange code, selects the appropriate route and charge rate for the call and passes this information back to the Register.

The information is in the form of a charging rate digit and from one to five routing digits. To avoid having to provide storage capacity in the Register for all these digits at once, it is arranged that they are passed to the Register one at a time as required. The Register uses the digit supplied by the Translator to further the setting up of the call and then makes a fresh demand for another digit, indicating to the Translator which one is required. The time taken by a Register to use a digit is far greater than the time the Translator takes to supply it. The Translator is therefore freed between demands for use by any other Register requiring its services.

The first digit returned to the Register from the Translator is used to select the appropriate charging rate in the Call Charger. Subsequent digits are used by the Register to operate switches in the originating and distant exchanges to complete the connexion. When the connexion has been completed the Register is released and made available for use with other Call Chargers in setting up further calls.

The Call Charger remains connected throughout the call and when the called subscriber answers, levies the charge by operating the callers exchange meter periodically at intervals of time depending on the distance between the calling and called subscribers charging groups.

The equipment has been developed in two different forms, one using conventional electro-mechanical components and the other using electronic techniques. The electronic version will be employed in the first installation at Bristol and the following description refers to this type of equipment.

The electronic equipment is based on the use of cold-cathode tubes. The 'voltage transfer' method of using cold cathode tubes has been adopted. With this method the output potential from one tube is sufficient to strike another tube, the potential being controlled by rectifier gates. Rectifier gating permits combinations of tubes to control the striking of another tube without mutual interference. Miniature selenium rectifiers are used to form the gates.

Register

Digits received by the register are in the form of dial pulses. These pulses are counted on the incoming counter which is a chain of cold-cathode tubes. When a pulse train ceases the number of pulses counted is stored on five tubes in 'two out of five' code by striking the appropriate two tubes. The incoming counter is then reset ready to count the next digit and a second counting chain is stepped to keep check of the number of digits received. Up to nine digits may be received and each is stored on a separate group of five tubes, requiring 45 tubes for digit storage. Digits to be transmitted by the register are received from the translator and stored temporarily on the counting chain tubes of the outgoing counter. The register then generates pulses—like those generated by a dial—and as each pulse is transmitted it is counted by the outgoing counter until the correct number has been transmitted. The register then receives the next digit to be transmitted from the translator and as soon as the 'inter train pause' switching period has expired, this digit is transmitted.

Translator

The electronic translator can deal with a register in a few milliseconds. This high speed of operation permits the translator to be connected to a register at regular intervals, whether the register requires the translator or not. The translator acts as a common control. Each time it is connected to a register it can decide what action, if any, is required. This common control arrangement permits a simple design of register since the register is merely a slave acting on instructions from the translator. Registers are connected in sequence and up to 40 may be controlled by one translator, each register being connected once every two-thirds of a second.

It will be appreciated that since a translator is common to as many as 40 registers a faulty translator could seriously disrupt service to subscribers. It is arranged therefore that any mis-operation is detected by check circuits and causes a standby translator to take over service automatically.

Thus in the rare event of a translator developing a fault only one call can be affected.

Construction

The equipment is mounted on standard sized telephone racks approximately 10ft 6in high and 4ft 6in wide. Racks for the electronic equipment are box section and divided into cubicles catering for 20 registers per rack of three translators per rack. Equipment within a cubicle is mounted on 'leaves' which are hinged together at the rear to form a 'book'. Cold-cathode tubes are mounted at the front of the leaves so that their glow can be observed through the red tinted front cover. Access to the equipment for fault location can be obtained by opening the front cover and parting the leaves at any desired position, free space at either side permitting the leaves to be opened to a wide angle. If work has to be carried out on the equipment it may be unplugged and removed from the rack.

Initial Installation

The initial installation at Bristol will comprise 66 registers and three translators. Two of the translators will be in service normally, the third acting as standby for either of the other two. This equipment can handle about 6 000 calls per hour, and can establish connexion to the called subscriber within a few seconds of completion of dialling.

The system has been devised by Post Office engineers and equipment for the initial installation has been designed and developed in co-operation with the General Electric Company Ltd.

Magnetic Drum Director

Known as the Magnetic Drum Director, this electronic telephone controlling equipment has been developed by Automatic Telephone and Electric Company Limited, and is a noteworthy technical improvement on the existing electro-mechanical equipment in use in London and other large cities throughout the world. Its functions are, however, basically the same—it must 'store' the dialled numbers, translate them into routing directions, and ensure that calls are put through in the shortest possible time.

The magnetic drum around which the new electronic director has been constructed consists of a bronze cylinder some twelve inches in diameter and about three inches deep. Its working surface is coated with approximately two ten-thousandths of an inch of nickel which forms the medium for the magnetic records. The records consist of sequences of magnetic 'dots' which can be packed closely enough together to obtain 100 dots to the inch of circumference and at least ten similar circumferential 'tracks' of dots to the inch of depth. The total capacity of the drum for dots is at least 110 000. In operation the drum rotates at about 1 800rev/min and dots may be recorded or reproduced at a rate of about 100 000 dots/sec.

The magnetic dots are coded into machine language to allow numbers and instructions to be built up in binary code, thus four dots are required to record a single digit, and seven sets of four dots to record a seven-digit number such as would be dialled by a caller.

The drum records are used in two ways. Some of the 30 tracks are used for remembering the translations likely to be required—about 700 in all. These records are virtually permanent in the sense that they are changed only when, for administrative reasons, it is necessary to alter a translation. The remainder of the tracks are used as control tracks—some provide the means for synchronizing the operation of the complete equipment—the others provide individual memories for switch control units of which there are 114.

The electronic equipment associated with the drum contains a scanner, driven by the synchronizing tracks, which, among other things, causes each switch control unit to be associated in turn with the particular portion of one of the tracks allotted to it. The switch control memory tracks provide means for keeping a running record of the state of each control unit and by continuously checking this running record the electronic equipment can determine what action is next required in each case.

The running record is kept up to date merely by recording the most recent record in place of the old one. In this electronic equipment and the drum can be time shared over 114 switch control units in as little as 17 milliseconds each without interfering with any other. Moreover, each of the 114 control units can be rescanned every 17msec so that changes of state of up to 60 changes per second are recognized. This permits considerable economies in apparatus and is one of the reasons for developing the trial equipment. The translation tracks are referred to whenever a switch control unit reaches an appropriate condition.

Maintenance Equipment

Recent Developments in Telephone Equipment

The London automatic telephine network serves some 1.35 million exchange lines, having about 2.25 million telephone instruments, connected to 235 automatic and 56 manual exchanges by nearly 2.5 million miles of pairs of paper-insulated copper wire in the lead-sheathed underground cables. About 35 million dialled telephone calls are made over the network every week.

Three automatic devices have been developed in London to aid the maintenance engineers in reducing the fault liability of the whole system, so reducing the cost of maintenance.

Automatic Telephone Subscriber

The possible combinations of lines and exchange equipment that could be used to complete a telephone call from a P.B.X. extension in the City to a subscriber on, say, Harrow exchange amount to several hundred thousand. It is almost impossible to repeat the particular combination that gave rise to a complaint of call failure and so this device has been developed to help in locating the cause of such failures. It makes calls in sequential order to telephone numbers at upwards of 100 other telephone exchanges where the call is received on equipment that simulates the answering condition on a telephone call and also provides means of verifying the called number. Should a call fail for any reason, the calling equipment holds the connexion and draws the attention of the exchange maintenance engineer to the condition. The call is then traced and the defect that caused the failure is located and put right.

Line Insulation Tester

Incipient trouble arising from falling insulation resistance on a telephone line can be detected much more readily by adopting a comparatively high standard of insulation resistance, 2MΩ for subscribers' telephone lines. The defect causing the trouble, generally a small crack or hole in the lead sheath of a telephone cable, can then be located before the insulation resistance has fallen to such a low value, due, for example, to water entering the cable and saturating the insulating paper during a period of wet weather, that the line becomes unserviceable. To achieve this objective, tests must be made once each week and manual testing methods are out of the question. This automatic device tests each telephone line connected to a telephone exchange in numerical order and it will record the telephone number of each line that fails to pass the test. Lines are tested at the rate of about 600 per hour and an analysis of the route taken by those cable pairs serving the lines that failed the test indicates that section of cable in which incipient trouble is developing. It can then be located and cleared, so preventing a cable fault or a complete cable breakdown from occurring.

Automatic Testing of Subscribers' Telephone Lines and Instruments

Testing of telephone lines and instruments is at present done manually from a test desk in the exchange. This device enables a faultsman or an installer to make a complete test of a telephone line without requiring any co-operation from the exchange staff. The test is completed in 15 seconds and any faulty condition that may be found is advised to the faultsman by a verbal announcement.

Short News Items

SIMA (Scientific Instrument Manufacturers' Association) announce that their 1958 Convention will be held at the Majestic Hotel, Harrogate, from 6-9 November. Mr. P. J. Ellis, O.B.E., of R. B. Pullin & Co Ltd, the Honorary Treasurer of SIMA, has been nominated Chairman of the Convention Committee whose task is to settle a programme and organize the event. This will be the seventh annual convention but the first to be held in the North, the previous ones having been at Eastbourne.

The Metal Physics Committee of the Institute of Metals is organizing a one-day symposium on 'Metallurgical Aspects of Semi-Conductors,' to be held on Tuesday, 25 February, at the College of Technology, Gosta Green, Birmingham. A number of short papers will be presented but will not be available in advance of the meeting. Visitors will be welcome; tickets are not required. In conjunction with the meeting, an exhibition is being arranged at the College by the Royal Radar Establishment, Great Malvern. This will be open on 25 February and also on the evening of Monday, 24 February.

The Institution of Electrical Engineers announces that at a meeting held on 20 December, Group B—The British Group for Computation and Automatic Control of the British Conference on Automation and Computation—was formally constituted, comprising some twenty-three learned societies as its members. Mr. T. E. Goldup, C.B.E. (President of The Institution of Electrical Engineers), was elected Chairman of the Group, with Messrs. J. F. Coales, O.B.E. (Society of Instrument Technology), and E. M. Renals (Institute of Cost and Works Accountants) as Vice-Chairmen. Mr. J. D. Green (Institute of Chartered Accountants in England and Wales) was elected Honorary Treasurer, and Mr. W. Bamford (The Institution of Electrical Engineers) Honorary Secretary, and the offer of The Institution of Electrical Engineers to provide secretarial services for the Group was accepted.

The International Instrument Show to be held at Caxton Hall during the last week of March will be almost one-third larger in floor area than the 1957 exhibition and will occupy the Great Hall and Court Room. Tickets are available on request from the sponsors, B & K Laboratories Ltd, 57 Union Street, London, S.E.1.

An exhibition of Airmec Electronic Instruments will be held at the Napier Hall, Vincent Street, London, S.W.1, from 24-27 March. The complete range of Airmec electronic equipment, including several entirely new instruments, will be shown. Tickets for admission will be forwarded on request to Airmec Ltd, High Wycombe, Bucks.

The European Broadcasting Union has announced the introduction of a periodical entitled The E.B.U. Review. The new publication, which replaces the E.B.U. Bulletin, will appear in two parts, Part A Technical and Part B General and Legal. Separate English and French editions will be published. Part A is to be issued in January, March, May, July, September and November, and Part B in February, April, June, August, October and December. In addition to authoritative articles dealing with particular aspects of broadcasting engineering, Part A will give up-to-date information about the situation in all of the frequency bands allocated to sound and television broadcasting, and also about plans and achievements in these fields in Europe and elsewhere. A specimen number of Part A is available on request to the Technical Centre of the European Broadcasting Union, 4 rue de la Vallée, Brussels. Single numbers of Part A cost 30 Belgian francs, the annual subscription being 150 Belgian francs. The combined subscription to Parts A and B is 300 Belgian francs, all the foregoing prices including postage by surface mail.

The BBC has placed orders for thirty television camera channels for the new Television Centre now being built at White City, London. Fifteen channels will be supplied by E.M.I. Electronics Ltd and fifteen by Marconi's Wireless Telegraph Co Ltd. The cameras will use 4½in tubes of the image orthicon type. This type of camera tube has been decided upon after extended trials under the conditions of operation that will be encountered. It is hoped that three of the studios at the new Television Centre will be brought into operation during 1961, and a fourth early in 1962. Of the thirty camera channels ordered, four working channels and one spare channel will be installed in each of the two larger of these studios, and three working channels and one spare channel in each of the other two studios. Others will be used as spares, and the remainder will be used for equipping additional studios as required.

Southern Instruments Computer Division have recently shipped a Film Analyzer to the Canadian Defence Research Board. The Film Analyzer is an automatic analogue computer capable of various computations on data supplied in the form of continuous lines on film or paper.

Chapman & Hall have been appointed publishers of books to the Institute of Physics, with the exception of those books already published by Edward Arnold Ltd. The Institute will continue to publish The Journal of Scientific Instruments, The British Journal of Applied Physics, and all supplements thereto.

Camp Bird Industries Ltd announce the formation of a new company in the audio field. This will be Electronic Reproducers Ltd, and it will be primarily concerned with the manufacture of crystal cartridges. The works will be sited at Bletchley, Bucks, and the company will be under the Chairmanship of Mr. P. J. N. Collaro. Dr. F. E. Templeman will be Technical Director.

The Institute of Physics at the University of Lund, South Sweden, is at present engaged in assembling an apparatus that is believed to be the largest of its kind in the world. It is an electron synchrotron for a tension of 1 200 000 000V and is to be used for studying heavy mesons and hyperons.

Mr. J. O. C. Whelans of the Mullard Radio Valve Co Ltd was awarded the M.B.E. in the New Year Honours List. Mr. Whelans is assistant to the Manager responsible for production activities of receiving-valve manufacture in the company's Southern factories, including those at Mitcham, Whyteleafe and Hove. He has been with the company for thirty-two years and is one of the leading technologists in receiving-valve manufacture.

Lieutenant-Colonel E. N. Elford, Manager of the Radar Division at Marconi's Wireless Telegraph Co, was awarded the O.B.E. in the New Year Honours List. This honour has been conferred in recognition of his work in connexion with the radar defences of Great Britain.

Vice-Admiral J. W. S. Dorling, C.B., M.I.E.E., is to retire from his appointment as Director of the Radio Industry Council, on medical advice, but not with effect until 31 October 1958. He was the Council's first Director, being appointed in 1946, immediately after the formation of the Council as the co-ordinating body of four associations in the industry.

Dr. H. W. Melville, Secretary of the Department of Scientific and Industrial Research, has been appointed to succeed Sir Ben Lockspeiser, K.C.B., F.R.S., as one of their delegates to the Council of the European Organization for Nuclear Research (C.E.R.N.).

LETTERS TO THE EDITOR

(We do not hold ourselves responsible for the opinions of our correspondents)

Electronic Filtering Circuit

DEAR SIR,—During the design of equipment containing a considerable number of pulse circuits it was found that conventional power supply filtering and decoupling was insufficient to prevent interaction between different circuits. However, d.c. stabilization was not required and the extra expense of regulated power supplies not warranted. Since the existing supplies had ample reserve of current it was possible to incorporate an electronic filtering circuit.

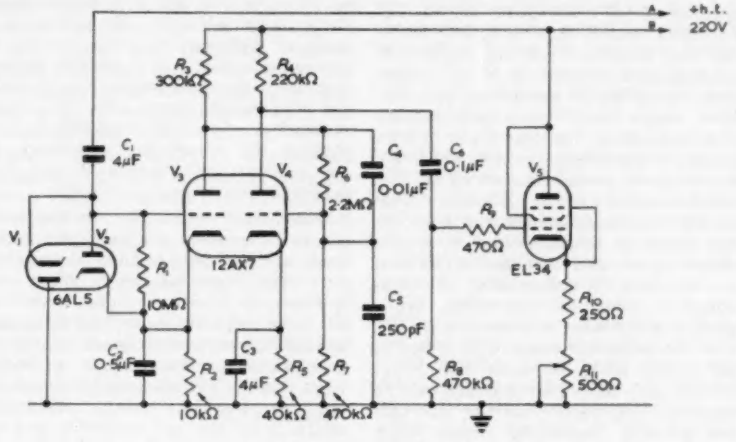

Fig. 1. The electronic filter circuit

The circuit (Fig. 1) consists of a two stage amplifier driving a shunt valve which presents an effective a.c. impedance of $(1 + g_m R_k)/Ag_m$ ohms, where A is the gain of the amplifier and g_m and R_k apply to the shunt valve. Since there is feedback, phase relationships are critical. Direct coupling is used in one stage to reduce the phase-shift and the time-constants of the other coupling circuits chosen to avoid low frequency instability. The input is taken directly from the h.t. supply line at the point where the most complete filtering is required: i.e. at the common h.t. distribution point. For this reason two h.t. leads are shown; a potential lead marked A, and a current lead marked B. This arrangement increases the effectiveness of the filtering many times by avoiding the presence of a common impedance in the h.t. lead. Such an impedance may only be a fraction of an ohm (fuses, etc.) but it is of the same order of magnitude as the effective a.c. output impedance and would unnecessarily add to it. The diodes included at the input prevent line voltage surges or steps of either polarity from biasing the first valve for long periods beyond its grid-base; without, however, restricting the maximum performance.

When measured, the effective a.c. impedance of the circuit was under 0·5Ω, and it reduced the ripple to less than 50mV in a high tension system using three conventional paralleled power supplies of 250V, 125mA each. This agrees with the calculated performance. Effective by-passing of R_k can further improve the performance if necessary. The value R_k is made adjustable so that the cathode current of the shunt valve can be made large enough to allow fluctuations in the external circuit to be cancelled. The current drawn should not exceed 70mA unless a further shunt valve is added.

This circuit has now been in continuous operation for over a year and has given completely satisfactory performance.

Yours faithfully,

R. G. T. BENNETT
C. S. L. KEAY
Physics Department,
University of Canterbury,
New Zealand.

"Dekatron"

DEAR SIR,—In your issue for November 1957 reference is made in an advertisement to dekatron tubes (page 61).

The writer is instructed to point out that "Dekatron" is a Trade Mark which denotes cold-cathode counting tubes manufactured by this company exclusively. We are concerned to maintain the distinctive character of this word, which should only be used in this sense.

Yours faithfully,

G. H. HILLIER,
Patents Department,
Ericsson Telephones Ltd.

Binary Coded Digitizers

DEAR SIR,—Mr. Tiffany in his recent very interesting article on Wind Tunnel Instrumentation, in your November issue, appears more pessimistic over the resolution and performance of Binary Coded Digitizers than development warrants.

In fact, with mechanical digitizers and torques of below 2oz in (in selected cases below 1oz in), disks with a resolution of 1 200 unambiguous coded outputs over 320° are already commercially available. No doubt if disk diameters in excess of 4½in were acceptable, higher resolutions than this would be obtainable.

But apart from the mechanical digitizers, there are non-contact type digitizers, such as the optical, in existence, which have—in the laboratory—given 1:10 000 over 360° on 6in disks and 1:1 000 over 360° on 2in disks, and although these are not yet commercially available there is great hope that by the end of 1958, by one technique or another, these resolutions will be accomplished. Being non-contact types, torques in the order of a few g.cm should be achieved and, of course, the life of digitizers should be considerably enhanced. These advanced types of digitizers should be capable of competing with the high speed chart recorders.

Yours faithfully,

R. F. COLVILE,
Hilger & Watts Ltd.

The author replies:

DEAR SIR,—I note with interest Commander Colvile's remarks regarding the possibility of higher resolution digitizers, but would refer him to the less compressed discussion of this point in a later article[1]. In the case of mechanical digitizers, diameters above 4½in are decidedly not acceptable and considerable compression would be desirable. The modest improvements in torque and resolution reported are welcome, but far removed from requirements existing now.

The ancillary equipment required to read out digitizers of the optical type is far more involved, and expensive, than many potential applications could tolerate. For multi-channel readout it is essential that the equipment associated with individual channels be cheap, simple and readily replaced. A complex, rapid central scanner or multiplexer may be justifiable if sufficient channels can be scanned and processed at a suitable rate.

I would be the first to welcome a commercially available, British digitizer of high resolution, but the phrase "in the laboratory" has a ring we have come to recognize as ominous. The equipment I have described has been in daily use for almost two years now and at the time of conception nothing at all was available commercially in spite of many projects 'in the laboratory' at that date. The need for these devices is now urgent.

Yours faithfully,

A. TIFFANY,
Aircraft Research Association Ltd.,
Bedford.

1. TIFFANY, A. A Simple Shaft Digitizer and Store. *Electronic Engng. 29*, 568, 1957.

BOOK REVIEWS

Light, Colour and Vision

By Yves Le Grand. (Translated from the French by R. W. G. Hunt, J. W. T. Walsh and F. R. W. Hunt). 512 pp. 125 figs. Demy 8vo. Chapman & Hall Ltd. 1957. Price 63s.

NOWADAYS many electronic engineers are perforce making their first real acquaintance with the difficult field of colorimetry, so that this book makes a particularly well-timed appearance.

Commencing with a comparatively terse and factual survey of the fundamentals of vision and photometry, the author then proceeds to explain at length the experimental observations upon which modern colorimetry is based and the physiological theories which have been advanced to explain these observations. Although initially only an elementary technical knowledge is assumed in the reader the text rapidly advances to a higher standard and is then copiously provided with references to books and articles from which the industrious may benefit. Unfortunately, it often appears that work thus described is considered as being of doubtful validity or that it is in conflict with other work which is also referred to, the reader being left to evaluate the evidence and come to a conclusion, though this could seldom be done by the inexpert.

Though the book is a positive mine of information, it is not an easy one to read. This is very largely because it is sometimes only too apparent that, as is stated by the author in his preface, the translation closely follows the French text. However, the information is there, and thanks to an excellent index it can readily be found. The book should be of particular value to those who are required to devise colorimetric experiments in new fields, for the probable causes of error are all described.

The book contains many valuable tables and diagrams and includes a bibliography of some thousand items. It will be of great value as a work of reference.

C. F. CHAPTER

Pressure Measurements in Vacuum Systems

By J. H. Leck. 144 pp. 79 figs. Demy 8vo. Published for the Institute of Physics by Chapman & Hall Ltd. 1957. Price 30s.

SOME years ago, the reviewer advocated in these columns the publishing of specialist works in vacuum physics rather than the frequent publication of all embracing texts which were too general to be of value to advanced workers. Thus it was with some sympathy that your reviewer read the opening statement to Mr. Leck's work that "Whilst several books have been written dealing with vacuum technology in general, none has yet given a detailed treatment of the measurement of pressure, nor am I aware of any text devoted exclusively to this subject." Apart from Dushman's detailed consideration of vacuum gauges covering 129 pages in his "Scientific Foundations of Vacuum Technique" which should not be ignored, Mr. Leck's statement is correct, and it is against this background that one judges how well he has used his opportunity.

In all there are six chapters devoted to mechanical manometers; thermal conductivity gauges, ionization gauges, the Knudsen radiometer gauge; surface reaction techniques and gauge calibration.

Considering the text as a whole one finds it difficult to understand why Mr. Leck never included a section on leak detection. It is true that types of leak detection apparatus are used which are not based on pressure measuring devices, but conversely nearly all the known forms of vacuum gauges are used for leak detection purposes either by simply measuring the rate of pressure rise in a system with a manometer or with dynamic procedures involving probe gases and hot wire or ionization gauges. Like the recipe attributed to Mrs. Beeton for jugged hare, one must first obtain a "vacuum" before its pressure can be measured accurately, and the fact that the pressure measuring device often with simple modification can be used to provide a leak free system is of great value.

One would also expect to have found a definition of what is meant by pressure, i.e., other than the useful technical data given on pressure units. Also, some of the relations of the kinetic theory might have been derived in the text instead of the distressing habit of referring the reader to one of three theoretical works for many of the equations quoted. Understandably the author has tried to free his work from extraneous matter, but a few pages devoted to kinetic theory would have been of value.

Some general items which should be corrected in future texts are: the use of the phrase "reflected molecules" on page 34 where the energy exchange between gas molecules and heated surfaces is discussed. It would be better to use the term *restituted* or *re-emitted* since the molecules may linger on the target for a finite time. The photograph in Fig. 3.16 of a Philips gauge head is indistinct. There is no reference in the Chapter on Radiometer Gauges of a useful paper by Steckelmacher (*Vacuum 1*, 266, 1951) in which early work by Spivak is corrected and extended. The simple glow discharge tube which is still used for indicating backing pressure is not dealt with.

Mr. Leck has usefully given the probable accuracy of the pressure indication for each type of instrument based on constructional and electrical factors and attention is also given to the effect on the gauge response of the nature of the gas being measured. However, there are cases, particularly in research, where it is insufficient merely to know the total pressure of the gas in the system however accurately, but one must also know the nature of its components and their partial pressures. Obviously chemical and other reactions occurring at the same total pressure will be quite different if in one case the residual atmosphere is a water vapour/air mixture and in another a hydrocarbon/air mixture, and so on. For example, the reduction of an oxide may critically depend upon the relative values of the partial pressures of hydrogen to water vapour in the residual gas. It is in this respect that the mass spectrometer (particularly the Omegatron type with its small volume) is such a valuable tool for indicating the nature and abundance of the residual gas components, and this might have been discussed briefly.

The chapter on surface reaction techniques is a useful pointer to the problems facing vacuum engineers in measuring "ultra high vacuum." When one achieves a vacuum of the order of 10^{-10}mm Hg collisions between gas molecules in transit have little importance (the mean free path of air molecules in air is 310 miles at this pressure!) but one may still obtain measurable effects from the gas molecules striking internal surfaces. Thus it will take several hours for a monomolecular layer to form on a clean active surface at this pressure. Apart from the unreliability of pressure instruments in this range, the use of pressure units is not essential and possibly high vacuum physicists will finally agree to a unit of measurement based on the monomolecular layer formation time using a given gas—target combination.

Often in industrial processing it is not necessary that the vacuum gauge should read the true pressure of the residual gas providing the gauge gives a repeatable value at which it is known that the process proceeds satisfactorily. As the author states in his Preface, instruments based on ionization processes are really density measuring devices, since they depend on the number of molecules occupying the volume through which the electrons pass. Thus to call an ionization gauge a pressure measuring device is a misnomer, which, however, is forgivable providing the conditions of measurement are constant. Also such gauges are commonly used on electronic apparatus where the process is affected by the total cross-sectional area of residual molecules in the path of high speed particles. Such a relation between the quantity measured and its effect on

the process being carried out is obviously desirable.

It follows from the views expressed here that "pressure measurements in vacuum systems" is really a part of a more general subject which could be called "Vacuum Measuring Instruments," i.e., devices for assigning a physical value to a rarified atmosphere in terms of the gas pressure, molecular density or rate of impingement of molecules on surfaces. This division also covers the three most important stages in general experience, e.g. (i) the vacuum used in many industrial processes for drying or metallurgy from 20mm Hg down to 10^{-3}mm Hg., (ii) the long mean free path range of importance in thermonic tubes and particle accelerators (10^{-4}-10^{-7}mm Hg) and (iii) the range in which gas bombardment of surfaces is of greatly reduced interest to those studying electron emission and surface chemistry (10^{-7}-10^{-11}mm Hg).

Mr. Leck has described vacuum gauges which can be used in each of the foregoing ranges, but a place still exists for a more comprehensive work on 'Vacuum Instruments' which is not restrained by consideration of pressure measurement. The opinion of your reviewer must, however, be considered alongside the fact that high vacuum technology has become part of the curriculum of many technical colleges and universities, and Mr. Leck's work will be a useful text within the reach of advanced students. The layout of the book and the drawings are of the high standard one associates with publications of the Institute of Physics.

L. HOLLAND

Britain and Europe

299 pp. 40 figs. Demy 8vo. The Economist Intelligence Unit. 1957. Price 15s.

THE main object of this book is to assess the impact of European Free Trade on British industry—whether the changes will be favourable or unfavourable, big or small. The E.I.U. has examined the prospects in detail for each main manufacturing industry, and it is clear that manufacturers as a whole will be considerably better off if there is a Free Trade Area than if the Common Market alone develops. Of the industries studied, covering some 85 per cent of total manufacturing industry, those likely to be adversely affected by 1970 within a Free Trade Area account for less than 15 per cent of the output.

The industries which will probably be better off within a Free Trade Area include: motor vehicles, chemicals (output estimated at 10-20 per cent more by 1970 than if there is a Common Market only); wool, electrical engineering, general engineering, rubber manufactures (output 5-10 per cent more); steel, hosiery, clothing (output up to 5 per cent more). The following industries should also be gainers: non-ferrous metals, metal manufactures, aircraft, shipbuilding, oil refining, building materials, glass, scientific instruments, sports goods. Cotton, rayon, paper, leather, and watches and clocks are likely to lose from Free Trade; the prospects for china, footwear and toys are also somewhat doubtful. Railway engineering, jute manufactures and furniture should be little affected.

Apart from the greater intro-European trade that will follow from the abolition of tariffs and quotas and from fairer competition, there should be a general quickening of the growth of national incomes and production. The industry studies show that the 'leaders' such as chemicals, motor vehicles and electrical engineering will be considerably stimulated, and in all sectors the efficient, faster growing units of production will benefit.

FBI Register 1958

1 138 pp. Royal 8vo. 30th Edition. Kelly's Directories Ltd. and Iliffe & Sons Ltd. 1957. Price 42s.

IN the following words the President of the Federation of British Industries, Sir Hugh Beaver, introduces this new edition. "I am glad to commend the 30th edition of the FBI Register to its readers in all parts of the world. The object of this annual publication is to spread the widest possible knowledge of the great range of British manufactured goods, so that prospective buyers will not only know what Britain makes but will also have a ready means of getting into contact with British firms supplying the goods or services they are seeking."

This comprehensive guide to a substantial cross-section of British industry lists the products and services of over 7 500 member firms under more than 5 400 alphabetical headings. In addition to the Classified Buyers' Guide there are seven other sections in the Register, giving addresses of companies and firms, and valuable information about Trade Associations, proprietary names, trade marks, etc. As the only authorized directory of the Federation of British Industries, the FBI Register is compiled by the publishers in close collaboration with the Federation.

BBC Handbook 1958

288pp. Demy 8vo. The British Broadcasting Corporation. 1957. Price 5s.

THE first edition of this handbook was published in 1928. The new edition goes a long way towards meeting the public interest in how the BBC is run, what it is doing and aiming to do.

A table of figures shows that the cost of television broadcasting increased from £2 675 per hour in 1956 to £3 256 per hour in 1957. Sound broadcasting costs also went up, from £540 per hour in 1956 to £575 in 1957.

The handbook shows how, subject to the requirements of the BBC Charter, the Corporation enjoys complete independence in the day to day operations of sound and television broadcasting.

One of the most impressive tables in the handbook lists no fewer than 50 countries throughout the world which regularly rebroadcast BBC overseas programmes.

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BRANCHES THROUGHOUT ENGLAND AND WALES

ELECTRONIC EQUIPMENT

A description, compiled from information supplied by the manufacturers, of new components, accessories and test instruments.

AUDIO OSCILLATOR

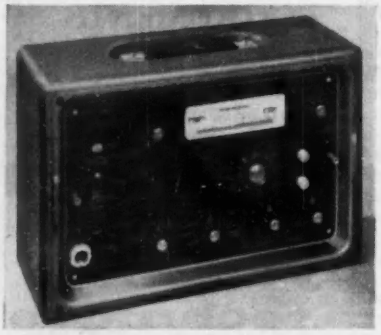
(Illustrated below)

Wayne Kerr Laboratories Ltd, Roebuck Road, Chessington, Surrey

THE wide range audio-frequency oscillator type S.121 is a high grade laboratory instrument providing a stable, controllable signal within the frequency range 10c/s to 120kc/s.

The novel dial display is designed for simple and rapid operation and permits either the selection of major intervals by means of switches, or the continuous fine control of frequency on an open horizontal scale.

Two alternative outputs are provided. An accurate 600Ω output incorporates a step attenuator covering the range +10dB to −70dB in 1dB steps on a reference level of 1mW. The second output provides a continuously variable control of voltage



from 0 to 30V in five decade ranges into an impedance of 3·3kΩ. The stability of the output level is to within 0·2dB over the whole frequency range.

The total harmonic distortion is better than 0·2 per cent above 300c/s.

Despite its high performance the instrument is compact, light and portable.

CRYSTAL OSCILLATOR FREQUENCY DIVIDER

(Illustrated above right)

Ericsson Telephones Ltd, Beeston, Nottingham

THIS is a general purpose instrument for laboratory and workshop use which has a wide range of applications such as the calibration of oscilloscopes and the standardization of oscillators.

The crystal oscillator and frequency divider can also be used as a source of time bases for use with any of the Ericsson range of unit construction equipment.

It provides four substandard crystal controlled frequencies, the basic frequency of the 100kc/s crystal oscillator having an accuracy of ·005 per cent. This fact, along with the unique circuit design which incorporates fully automatic amplitude stabilization, ensures a high degree of frequency stability.

Four frequency outputs are available, at front mounted Belling-Lee terminals, and these consist of a 100kc/s sine wave

and three semi-square wave outputs at frequencies of 10kc/s, 1kc/s and 100kc/s. The three semi-square wave frequencies are derived from the 100kc/s crystal oscillator by three multivibrator frequency dividers consisting of one double triode per stage and these select the required sub-harmonics.

Three pre-set potentiometers are provided to adjust the division ratio of the multivibrator circuits. These are accurately set before the instrument leaves the works and under normal circumstances should require no further attention.

The crystal oscillator and frequency divider type 124 can be adjusted for use with an a.c. mains supply of 100 to 125V or 200 to 250V at 40 to 60c/s a.c.

The instrument has its own built-in power supply employing standard full-wave rectification and retains its stability over a mains fluctuation range of ±10 per cent of nominal.

EXTENSIBLE LEADS

(Illustrated below)

Creators Ltd, Pinnsel Works, Sheerwater, Woking, Surrey

CREATORS LTD have introduced a new type of extensible lead, extremely small and light, as shown on the photograph.

These leads have an extension ratio of 4 : 1 and up to five conductors can be used in their construction, which has made them acceptable for use in the aircraft and electronic industry, and for use on counting machines etc. where power units can be detached from the main chassis without disconnexion.

They are also used on telephones, microphone hand sets, electric irons, kettles, clippers, etc. A large manufacturer of clocks has found that a 3in length of this cable attached to the back of an electric clock eliminates the problem of controlling slack cable when adjusting the clock.

The outside braiding is available in acetate or nylon, the latter being highly resistant to wear and abrasion.

TACHOMETER

(Illustrated below)

Racal Engineering Ltd, Western Road, Bracknell, Berkshire

WHEN used in conjunction with Racal digital frequency meters, type SA.20 or SA21, this tachometer may be used for direct reading in shaft speed measurements, in the range 100/20 000rev/min.

The MA.38 consists of rotor with 60 teeth rotating in a magnetic field, so that an output of 60 pulses is obtained for every complete revolution of the rotor. This output is then fed to the frequency meter which can sample the shaft speed in rev/min.

Apart from the shaft speed measurement as such, the MA.38 may be used for other types of measurement. This may be accomplished by transforming linear or other movement to rotary action, and has uses in flow and process control etc.

The MA.38 may be used in conjunction with other digital frequency meters using a one second time base.

SCANNING UNIT

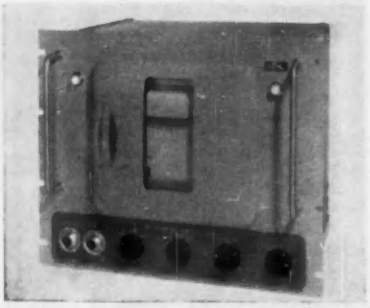
(Illustrated above right)

Isotope Developments Ltd, Beenham Grange, Aldermaston Wharf, Nr Reading, Berkshire

THE I.D.L. scanning unit type 701 employs a strip chart recorder for automatic plotting of pulse height spectra, in conjunction wth scintillation counting equipment incorporating a single channel pulse analyser and a ratemeter.

The chart recorder drum is direct-coupled to a 355° potentiometer. This varies the discriminating voltage of the pulse analyser, while the pen movement (controlled by the ratemeter) follows the corresponding pulse rate.

The scanning time can be switched to 10min or 1hr, and the chart length per scan is 6in. Each 6in record represents a scan over either the complete voltage range or the upper half of the voltage range, as selected by a 2-position switch.



The servo-type precision 10kΩ potentiometer has a linear accuracy of ±0·5 per cent. Calibration marks can be put on the chart at any required point by means of a switch which makes the recorder read full scale or zero. The exact zero of the potentiometer is indicated by means of a 'witness' mark.

A recording switch permits the upper half of the normal scan to be separately expanded into a full 6in record, thus giving the equivalent of a 12in chart length per full scan. Pre-set potentiometers are provided for accurately defining the voltage scanned.

The instrument is designed for standard Post Office rack mounting with dust cover, but it is also suitable for bench use. Special practical features of the design include a unspillable inkwell for the recorder, and quick-drying ink which does not smudge or grow mould. Mains input plugs at the rear permit connexion to existing equipment without the need for an extra mains supply point. The light-weight door swings completely clear or can be quickly removed to give easy access. A paper tear-off device is fitted, but the chart can hang freely through a slot in the bottom of the door, or can be wound on to a take-up spool.

PRECISION INSTRUMENT SWITCH

(Illustrated below)

W. G. Pye & Co. Ltd, Granta Works, Cambridge

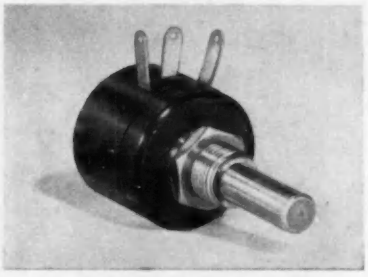
AN instrument switch of completely new design is undergoing a test to destruction at the factory of W. G. Pye & Co. Ltd. Although 17 million operations have been performed, which is equivalent to some thirty years of service, the performance of the switch remains virtually unchanged—in fact, the stability has improved within the rather narrow range specified.

No maintenance was necessary and test conditions have been rather more severe than would be encountered in service.

The overall switch resistance is approximately 0·7mΩ and the variation of contact resistance is ±20μΩ. The overall resistance drift during the life of the switch is ±50μΩ. Thermal e.m.f. is 0·008μV/°C with uniform change of temperature. Temperature gradient across the switch produces a maximum of 0·025μV/°C.

The stationary contacts are mounted in a strong insulating frame and the set of brushes makes a bridge contact between pairs of adjacent bars in a truly symmetrical manner. The brush itself is composed of several contact springs, each of which is independent of the others and unrestricted in its movement. Low and consistent contact resistance is achieved without high contact pressure and mechanical wear. The moving contacts are totally enclosed.

The stability of switch resistance and the virtual elimination of thermal e.m.f.s make possible improved designs in potential and resistance measurements, giving greater precision with simplified circuits and operating techniques. Long life without maintenance and robustness of construction also allow greater reliability in instruments, where precision requirements are less critical.



MINIATURE POTENTIOMETER

(Illustrated above)

Reliance Manufacturing Co. (Southwark) Ltd, Sutherland Road, Walthamstow, London, E.17

THIS miniature wire-wound potentiometer has been developed as a standard commercial version of the type RVW13 and 14 as called for in the Joint Services Specification RCL121.

It is available in a resistance range (linear low only) of 5Ω to 50kΩ with a tolerance of ±5 per cent above 100Ω and ±10 per cent below 100Ω It has a rating, with the whole element uniformly loaded, of 1W at 20°C ambient uniformly mum working voltage between spindle and track is 500V d.c.

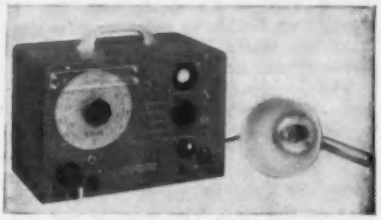
STROBO-TACHOMETER

(Illustrated above right)

C. F. R. Giesler Ltd, Small Hall, River Place, Islington, London, N.1

THIS is a portable instrument for use as an accurate and easily operated stroboscope; and as a tachometer for rapidly measuring the speed of rotating or reciprocating mechanisms.

The control box contains a stable generator of electrical impulses, the frequency of which is under the control of the operator; the impulses are used to trigger the stroboscopic lamp, which will thereupon flash at a rate governed by the impulse generator. The generator pulse-rate is adjusted by turning a large dial, which is clearly marked in revolutions per minute, and the range of the instrument is further extended by a 'range switch', according to which the readings of the main dial are to be multiplied by 1, 10 or 100.



In addition to the normal lamp supplied with the strobotachometer, a socket is provided to permit of the instrument being used for driving a high powered stroboscope for photographic purposes.

When the instrument is used alone, a shaft-driven contactor unit with phase change can be supplied to drive the stroboscope, and for this purpose an external contactor socket is provided on the panel. This attachment permits for exact synchronization of the stroboscope with the rotating machine under test—thus providing facilities for close examination of the test rotor in any position around the cycle.

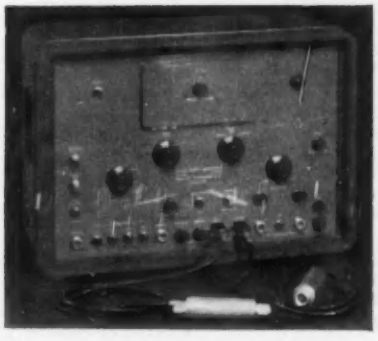
The speed range is 150 to 13 000rev/min. For calibration the instrument is fitted with a 1in cathode-ray tube, which indicates a characteristic wave-form when the instrument is operating at 50c/s or 3 000rev/min. The main rev/min dial is set to 3 000rev/min and a control switch is adjusted until the characteristic pattern is visible on the cathode-ray tube. The instrument is then accurate to ±1 per cent throughout.

SWEEP GENERATOR

(Illustrated below)

Marconi Instruments Ltd, St. Albans, Hertfordshire

MARCONI Instruments Ltd announce the introduction of a new 20Mc/s sweep generator, type TF1099. This high-quality video-frequency sweep generator, in conjunction with a suitable oscilloscope, enables response measurements to be made with a discrimination exceeding 0·01dB. It is primarily designed for the precise alignment of



monochrome or colour-television transmitter and studio equipment, but is equally applicable to radar or television receivers where the highest order of measurement accuracy is required.

The sweep starts at a frequency of less than 100kc/s and extends to an upper frequency that is continuously variable up to 20Mc/s; the lower frequency limit is locked to the start of the sweep in order to ensure a steady display on the c.r.o. The level of the frequency-swept signal is variable from 0·3 to 3V peak-to-peak, and the selected output level is held constant to within −0·1dB—a factor that contributes materially to a high order of measurement accuracy. A 250V time-base waveform, synchronized to the sweep frequency, is provided for connexion to the X-plate of the c.r.o., and a series of marker pips at 1Mc/s intervals is available for superimposing on the display to facilitate accurate frequency identification.

As well as providing facilities for conventional response measurement involving the display of the frequency-swept output of the apparatus under test, the TF1099 includes special circuits for precision differential measurement. For the differential method, the overall gain of the apparatus under test is reduced to unity by means of an external attenuator, and the outputs of the sweep generator and of the apparatus are both sampled, the two signals are then combined and the amplified difference voltage is displayed on the c.r.o.

An alternative version of this instrument, the TF1099/1, is electrically identical, differing only in that it has neither case nor mains lead and is intended for mounting in a standard 19in rack.

LOW VOLTAGE STABILIZED POWER UNITS

(Illustrated above right)

Roband Electronics Ltd, 33 Mountgrave Road, Highbury, London, N.5

THE conventional thermionic valve stabilized supply is not suitable for low voltage high current applications for the following reasons:—

(1) A negative stabilized line is required to operate the feedback amplifier.

(2) A large number of series valves are required to handle the current involved.

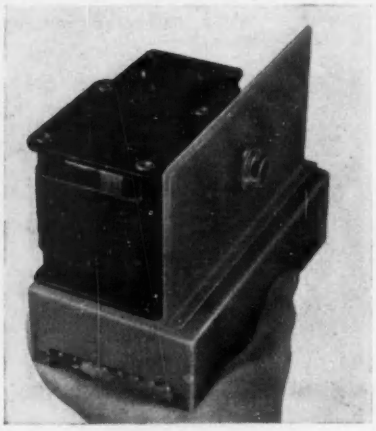
These factors lead to an unnecessarily large and expensive unit which is also wasteful in power efficiency, especially when one considers the heater power which is required for the rectifiers and series valves.

With this in mind, a series of miniature transistorized units have been developed in which no heater supply is required. A fixed output voltage is provided, either rail of which may be earthed, and a current of up to 1·0A d.c. can be drawn.

Briefly, the circuit details are as follows. A bridge rectifier system employing germanium junction rectifiers feeds a transistor circuit, the input stage of which compares and amplifies the difference voltage between a reference source and the output. This is amplified again and then fed into a power transistor in such a way as to reduce the difference voltage to nominally zero. The reference source employs two reference tubes and filtering is such that the stabilized output has less than 1mV ripple content.

The unit may be mounted in either the horizontal or vertical plane by means of brackets which are provided. Special attention has been paid to the component layout and this, coupled with a colour coded wiring system, enables servicing to be effected in the minimum time. A partially enclosed tag strip is provided for the external connexions.

A generously rated C-core transformer and choke, made to RCS215/H2 requirements, ensures that the temperature rise of the unit is kept to a practical minimum. Conservatively rated rectifiers and transistors, and the use of high stability



carbon resistors in place of wirewound types, ensures prolonged trouble-free service.

These units are available for a wide range of output voltages between 1·4V and 24V.

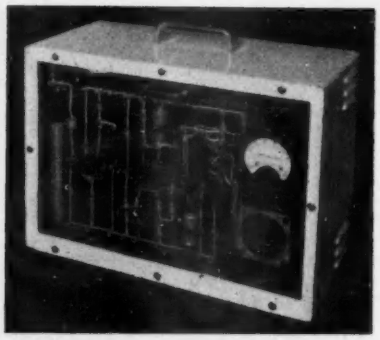
DEMONSTRATION GEIGER COUNTER

(Illustrated above right)

Buradept Ltd, Erith, Kent

THIS instrument has been designed in collaboration with A.E.R.E., Harwell, as a demonstration model for educational, services training and civil defence authorities. The monitor can be used for innumerable instructional experiments to illustrate the operation of gamma radiation monitors.

It is self-contained, mains operated and complete with the usual controls; oral and visual indication of counting rate is also provided. The monitor has a Perspex front panel which is engraved with the multi-coloured counting circuit and the actual components are mounted behind the panel. The engraved circuit is illuminated by edge lighting of the Perspex front panel and additional internal lighting can be used to illuminate the components. The various circuit waveforms are also shown on the Perspex.



The power unit is built on a separate chassis which slides into the main box and is accessible by removal of the rear cover. A special compartment for the mains lead is provided at the bottom of the carrying case.

The counting circuit comprises:

(a) Signal amplifier,

(b) Pulse shaper and counting rate-meter,

(c) Loudspeaker amplifier.

Standard practice is followed whereby the negative going pulses from the Geiger counter are fed into the control grid of a cathode coupled signal amplifier. The amplifier pulses are fed into a pulse shaper and thence into the output amplifier which drives the loudspeaker.

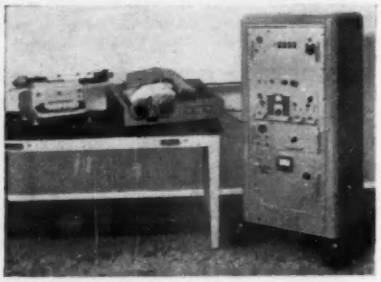
The Geiger counter used is of the halogen quenched type employing a gas mixture of neon, oxygen and bromine. One of the standard college experiments is to plot a counter plateau of this type of tube and the monitor lends itself admirably for such demonstrations.

The monitor is of robust construction contained in a portable cabinet 15in by 11in by 7in and the weight is approximately 27 lb.

TRACE READING EQUIPMENT

Southern Instruments Ltd, Frimley Road, Camberley, Surrey

ON page 614 of the December 1957 issue a description of the automatic trace reading equipment type K1020 was given. The photograph accompanying this description was, however, of the simpler type K1015 equipment. A photograph of the K1020 is reproduced below.



Notes from NORTH AMERICA

I.R.E. News

ELECTION OF PRESIDENT

Donald G. Fink, Director of Research of the Philco Corporation, has been elected President of the Institute of Radio Engineers for 1958. Mr. Fink succeeds John T. Henderson, Principal Research Officer of the National Research Council, Ottawa, Canada, as head of this international society of 62 000 radio engineers and scientists.

During 1933-1934, Mr. Fink was a research assistant in the M.I.T. departments of electrical engineering and geology. From 1934 to 1952 he was on the editorial staff of "Electronics," becoming Editor-in-Chief in November, 1946. Since 1952, he has been associated with the Philco Corp. as Director of Research for radio, television and appliances.

FELLOWSHIP AWARDS

Seventy-five leading radio engineers and scientists from the United States and other countries were named Fellows of the Institute of Radio Engineers by the Board of Directors at its November meeting held in New York City. The grade of Fellow is the highest membership grade offered by the I.R.E. and is bestowed only by invitation on those who have made outstanding contributions to radio engineering or allied fields.

The recipients of the Fellow award, which takes effect January 1, 1958, include one from Brazil, one from Canada, and three from England—J. A. Smale, Frank H. Wells and Arnold F. Wilkins.

Texas Instruments and IBM Agreement

Texas Instruments Incorporated announced recently that it had signed an agreement with International Business Machines Corporation under which both companies will work together in the area of transistors for data processing machines.

The agreement is expected to expedite progress in the area of interest of both companies through the exchange of technical information pertaining to transistors. Each company will protect the confidential nature of the information exchanged between them.

The agreement provides that IBM will purchase from TI a substantial portion of its expanding future commercial transistor needs. It places no restrictions on either company's present or future relations with other customers and suppliers.

Low Frequency Mechanical Oscillator

This miniature low frequency mechanical oscillator, manufactured by the Applied Science Corporation of Princeton is packaged in a hermetically sealed container measuring 2¼in square by 5in in length. The complete package weighs only 13oz. The output of the oscillator is a square pulse generated at 150c/s. The oscillator is essentially a sampling switch with a commutator-segment-type construction and two adjustable graphite brushes. This type of design allows the switch to handle currents up to 1A without adverse effects on switch life. The commutator is constructed with three make-before-break channels. The two brushes commutate the segments and pick up three pulses per revolution. The switch is designed so that the switch circuit is completed only when both brushes are on the same segment. This makes it possible to vary the width of the pulses from 10 to 80 per cent of total channel width by adjusting the distance between the brushes. This adjustment may be made by the operator while the oscillator is running. The model X-00006 is presently powered by a 9 000rev/min, 115V, single-phase, 400c/s drive motor; however, other motors are available.

Bell Telephone Developments

The following have been announced recently by the Bell Telephone Laboratories.

TRANSPARENT MAGNETIC OXIDES

A new class of magnetic oxides, structurally distinct from ferrites, has recently been discovered. These materials, known as rare-earth-iron garnets, are transparent, permitting the internal magnetic domain structure to be seen with a polarizing microscope.

The discovery of ferrimagnetism in these garnets was made first at the Laboratoire Electrostatique et De Physique du Metal of the Institute Fourier in Grenoble, France, and independently by S. Geller and M. A. Gilleo of Bell Telephone Laboratories.

Most magnetic materials, metals and ferrites alike, are opaque to visible light. Thus, their internal magnetic structure is not visible, and the way magnetic domains are oriented within them has been inferred from reflection of polarized light by their surfaces or by delineating domain boundaries at these surfaces with colloidal magnetic oxides.

Yttrium iron garnet, $Y_3Fe_2(FeO_4)_3$, is the most completely studied member of this new garnet family. It has a Curie temperature of 545°K and a spontaneous magnetization at zero temperature and infinite field of 4·96 Bohr magnetons per molecule, close to the theoretical value of 5·0. This magnetization results from super-exchange interactions through the O^{2-} ions between Fe^{3+} ions in crystallographically different positions in the cubic lattice. The number of these interactions per Fe^{3+} ion in yttrium-iron garnet is 3/5 that in a ferrite and, correspondingly, the observed Curie temperature of 545°K is 0·64 of that for magnetite (848°K).

Of great interest is the fact that yttrium-iron garnet contains magnetic ions with but a single valence. Both X-ray and neutron diffraction studies have shown clearly that, unlike the ferrites, the interactions between identical magnetic ions wholly occupying two different crystallographic sites are responsible for ferrimagnetism in the garnet structure.

In yttrium-iron garnet the width of the ferrimagnetic resonance absorption line at 9 300 and 24000Mc/s depends on crystallographic direction. Line widths of only 0·8 oersted were observed along the [100] direction in thin disks at 10 000 Mc/s, when the temperature was held at 540°K. These line widths increased with decreasing temperature and passed through peak values of several hundred oersteds between 65°K and 4·2°K.

A polarized light beam passing through the transparent magnetic domains in rare-earth-iron garnets has its plane of polarization rotated in one direction in one domain but in the opposite direction in an adjacent and oppositely magnetized domain. This Faraday rotation is wavelength-dependent and amounts to several degrees per mil of thickness; it makes the domains within the crystals clearly visible.

AUTOMATIC READING MACHINE

An experimental device the size of a portable typewriter that can read handwritten numerals or identify numerals as they are being written was announced recently.

The machine recognizes numbers as they are being written and indicates the numeral by lighting up the correct digit on a numbered panel. The writing is done with a metal stylus on a specially-prepared writing surface. Two dots, one above the other, are used as reference points. Seven sensitized lines extend radially from these two dots. Numerals are recognized by the machine, depending on which lines are crossed.

To clear the device for the next number, the writer touches the stylus to a special plate which causes the previous number to be 'erased.'

To recognize previously written numerals, such as those on a long distance telephone ticket, it is necessary to write with a pencil containing a conductive lead. The ticket is then inserted in the machine into a special slot under a plate that has seven sensitized lines. The machine then uses the same principle for recognizing numbers already written as it does for the ones written on the machine with the stylus. It determines which sensitized lines have been crossed and indicates the proper number by illuminating a numeral on the lucite panel. This information could be transferred to an accounting machine, computer or other data processing device.

The device is operated from flashpoint batteries and requires no outside power source. Its small size is made possible by the use of transistors.

Meetings this Month

THE BRITISH COMPUTER SOCIETY

Date: 17 February. Time: 6.15 p.m.
Held at: York Hall, Caxton Hall, London, S.W.1.
Lecture: Mental Arithmetic, an Historical Review with Demonstrations.
By: A. C. Aitken.

THE BRITISH INSTITUTION OF RADIO ENGINEERS

Date: 5 February. Time: 6.30 p.m.
Held at: The London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.
Lecture: Radio Investigations during the International Geophysical Year.
By: W. J. G. Benyon.
Date: 26 February. (Time and place as above).
Lecture: A Long Range Navigational Aid.
By: C. Powell.

South Wales Section

Date: 26 February. Time: 6.30 p.m.
Held at: Glamorgan Technical College, Treforest.
Lecture: Industrial Television.
By: R. Swinden and J. E. H. Brace.

South Midlands Section

Date: 28 February. Time: 7 p.m.
Held at: North Gloucestershire Technical College, Cheltenham.
Lecture: Some Advanced Applications of Information Theory.
By: P. H. Blundell.

West Midlands Section

Date: 12 February. Time: 7.15 p.m.
Held at: Wolverhampton Technical College, Wulfruna Street, Wolverhampton.
Lecture: Industrial Applications of Radio Isotopes.
By: R. F. Armitage.

North Western Section

Date: 6 February. Time: 6.30 p.m.
Held at: Reynolds Hall, College of Technology, Manchester, 1.
Lecture: Electronic Musical Instruments.
By: Alan Douglas.

Merseyside Section

Date: 19 February. Time: 7 p.m.
Held at: Birkenhead Technical College.
Lecture: Closed-Circuit Television.
By: J. G. M. Downes.

Scottish Section

Date: 20 February. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow.
Lecture: Frequency Response Instrumentation for the Analysis, Design and Production of Servomechanisms.
By: G. R. Swainston.
Date: 21 February. Time: 7 p.m.
Held at: Department of Natural Philosophy, The University, Edinburgh.
(Repeat of above lecture.)

THE INSTITUTION OF ELECTRICAL ENGINEERS

All London meetings, unless otherwise stated, will be held at the Institution, commencing at 5.30 p.m.

Ordinary Meeting

Date: 6 February.
The Forty-Ninth Kelvin Lecture: High-Polymers.
By: H. W. Melville.

Faraday Lecture

Date: 12 February. Time: 6 p.m.
Held at: Central Hall, Westminster, London, S.W.1.
Lecture: The Electrification of the British Railways.
Prepared by the late G. H. Fletcher.
Delivered by: R. Ledger.
(Admission by ticket available on receipt of a stamped addressed envelope.)

Measurement and Control Section

Date: 4 February.
Lectures: Temperature Transients in Gas-Cooled Thermal Nuclear Reactors.
By: J. H. Bowen and E. F. O. Masters.
Boron-Trifluoride Proportional Counters and The Design, Performance and use of Fission Counters.
By: W. Abson, P. G. Salmon and S. Pyrah.
The Application of Digital Computers to Nuclear-Reactor Design.
By: J. Howlett.
Date: 18 February.
Lecture: Magnetic Tape for Data Recording.
By: C. D. Mee.

Radio and Telecommunication Section

Date: 19 February.
Lecture: The Relation Between Picture Size, Viewing Distance and Picture Quality with special reference to Colour Television and to Spot-Wobble Techniques.
By: L. C. Jesty.
Date: 24 February.
Informal evening on Stereophonic Recording on Gramophone Discs.
Talk by: H. A. M. Clark.

East Midland Centre

Date: 4 February. Time: 6.30 p.m.
Held at: E.M.E.B. Service Centre, Derby.
Lecture: Automatic Circuit Reclosers.
By: G. F. Peirson, A. H. Pollard and N. Care.
Date: 13 February. Time: 7.30 p.m.
Held at: The George Hotel, Kettering.
Lecture: 275kV Transmission Lines.
By: J. D. Pierce.
Date: 20 February. Time: 7.15 p.m.
Held at: The Albert Hall, Nottingham.
Faraday Lecture: The Electrification of the British Railways.
Prepared by the late G. H. Fletcher.
Delivered by: R. Ledger.

Cambridge Radio and Telecommunication Group

Date: 4: February. Time: 8 p.m.
Held at: The Cavendish Laboratory, Free School Lane, Cambridge.
Informal evening on Problems of Sound and Television Broadcasting Coverage.
Talk by: G. Millington.
Date: 25 February. Time: 8 p.m.
Held at: The Physiological Laboratory, Cambridge.
Lecture: The Eye as a Television Camera.
By: F. W. Campbell.

Mersey and North Wales Centre

Date: 3 February. Time: 6.30 p.m.
Held at: The Town Hall, Chester.
Informal evening on Domestic High-Fidelity Reproduction.
Talk by: J. Moir.
Date: 17 February. Time: 6.30 p.m.
Held at: The Royal Institution, Colquitt Street, Liverpool.
Discussion of the Report on The Supply and Training of Teachers for Technical Colleges.
Introduced by: Willis Jackson.

North-Eastern Radio and Measurements Group

Date: 3 February. Time: 6.15 p.m.
Held at: King's College, Newcastle upon Tyne.
Informal Lecture: Domestic High-Fidelity Reproduction.
By: J. Moir.
Date: 17 February. (Time and place as above).
Informal Lecture. The Measurement of High Voltages with Indicating or Recording Instruments.
By: G. W. Bowdler.

Tees-Side Sub-Centre

Date: 5 February. Time: 6.30 p.m.
Held at: Cleveland Scientific and Technical Institute, Corporation Road, Middlesbrough.
North-Eastern Centre Chairman's Address.
By: T. W. Wilcox.

North Midland Centre

Date: 27 February. Time: 6.30 p.m.
Held at: The Yorkshire Electricity Board, Ferensway, Hull.
Lecture: British Columbia-Vancouver Island 138kV Submarine Power Cable.
By: T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson.

South-East Scotland Sub-Centre

Date: 4 February. Time: 7 p.m.
Held at: The Carlton Hotel, North Bridge, Edinburgh.
Lecture: Electric Control of Stage and Television Lighting.
By: F. P. Bentham.
Date: 12 February. (Time and place as above).
Lecture: The Relation Between Picture Size, Viewing Distance and Picture Quality, with special reference to Colour Television and to Spot-Wobble Techniques.
By: L. C. Jesty.
Date: 18 February. (Time and place as above).
Lecture: British Columbia-Vancouver Island 138kV Submarine Power Cable.
By: T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson.

South-West Scotland Sub-Centre

Date: 5 February. Time: 7 p.m.
Held at: The Institution of Engineers and Shipbuilders, 39 Elmbank Crescent, Glasgow, C.2.
Lecture: Electric Control of Stage and Television Lighting.
By: F. P. Bentham.
Date: 11 February. Time: 7 p.m.
Held at: The Royal College of Science and Technology, George Street, Glasgow, C.1.
Lecture: The Relation between Picture Size, Viewing Distance and Picture Quality, with special reference to Colour Television and to Spot-Wobble Techniques.
By: L. C. Jesty.

South Midland Radio and Measurements Group

Date: 24 February. Time: 6 p.m.
Held at: The James Watt Memorial Institute, Great Charles Street, Birmingham.
Lecture: Radio Research and the International Geophysical Year.
By: R. L. Smith-Rose.

South Midland Supply and Utilization Group

Date: 10 February. Time: 6 p.m.
Held at: The College of Technology, Birmingham.
Lecture: British Columbia-Vancouver Island 138kV Submarine Power Cable.
By: T. Ingledow, R. M. Fairfield, E. L. Davey, K. S. Brazier and J. N. Gibson.

North Staffordshire Sub-Centre

Date: 18 February. Time: 7.30 p.m.
Held at: The Victoria Hall, Hanley.
Faraday Lecture: The Electrification of the British Railways.
Prepared by the late G. H. Fletcher.
Delivered by: R. Ledger.

Rugby Sub-Centre

Date: 11 February. Time: 6.30 p.m.
Held at: Rugby Technical College.
Lectures: The Development of Variable-Speed High-Power Drives for Large Wind Tunnels, and A Variable-Frequency Power Installation for Large Wind-Tunnel Drives.
By: P. McKearney, L. S. Drake and E. G. Mallalieu.
Date: 25 February. (Time and place as above).
Lecture: The Importance of Research in Hearing and Seeing to the Future of Telecommunication Engineering.
By: E. C. Cherry.

Southern Centre

Date: 10 February. Time: 2.30 p.m. and 6.30 p.m.
Held at: The Guildhall, Southampton.
Faraday Lecture: The Electrification of the British Railways.
Prepared by the late G. H. Fletcher.
Delivered by: R. Ledger.
Date: 26 February. Time: 6.30 p.m.
Held at: The C.E.G.B. Offices, Portsmouth.
Lecture: Route Selection and Cable Laying for the Trans-Atlantic Cable System.
By: R. J. Halsey.

Hatfield District

Date: 7 February. Time: 7 p.m.
Held at: Hatfield Technical College.
Lecture: Colour Television.
By: P. C. Kidd.

THE TELEVISION SOCIETY

Date: 7 February. Time: 7 p.m.
Held at: The Cinematograph Exhibitors' Association, 164 Shaftesbury Avenue, London, W.C.2.
Lecture: The Effects of Noise in Television Transmission.
By: T. Kilvington.
Date: 20 February. (Time and place as above).
Lecture: Test Equipment for Colour Television Receivers.
By: F. H. Cohen and D. C. Kidd.

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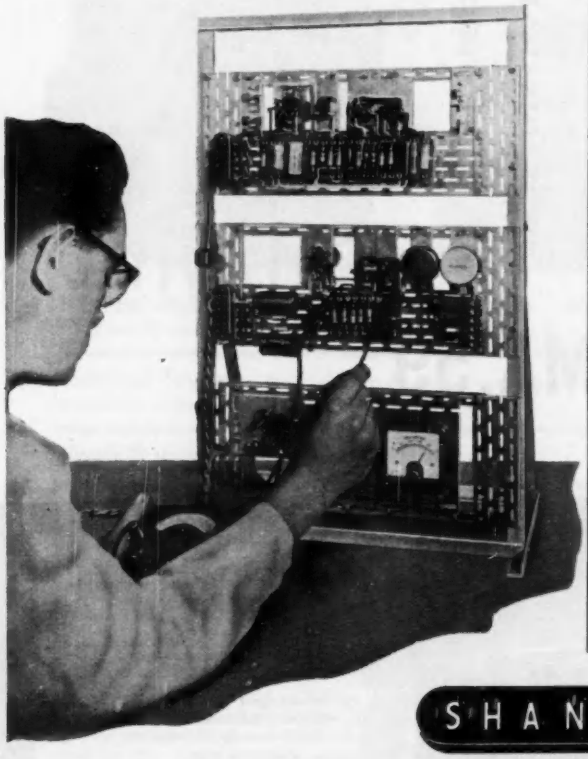

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A rigid vertical rack, plus slotted plates, plus special holder plates. The holder plates are pre-punched to take standard valve holders, potentiometers, switches, terminals, plugs, sockets, meters, etc., and have pronged ends so that they may be slid along the slotted plates. This enables holes to be moved even after assembly and wiring, without disturbing other components. The slotted plates may be assembled in any required arrangement and used to support components, such as tag panels, chokes, transformers, terminal blocks, etc., for which special holder plates are not needed.

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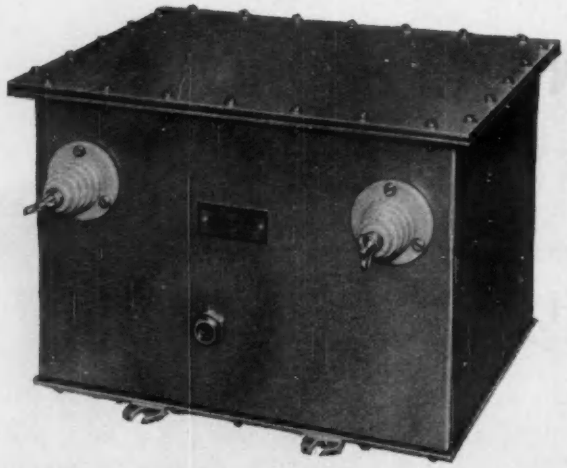

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The unit is designed to operate from an unbalanced 50 Ohm source into a balanced 500 Ohm output. Two types of transformers are available:—

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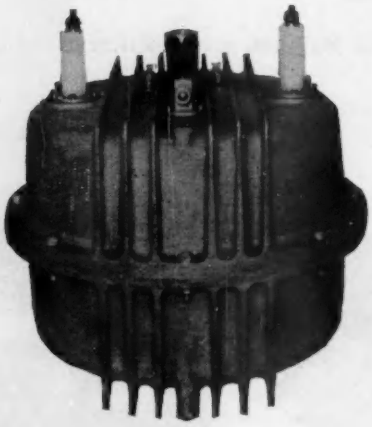
TECHNICAL SPECIFICATION : MA. 59A & MA.59B

Operating Temperatures.	+55°C max. ambient.
Construction.	Transformer is fitted in a cylindrical finned cast light alloy case, fully weatherproof, and mountable in any position, designed for external use, or in a rectangular light alloy case designed for indoor application and occasional outdoor use.
Termination.	Primary into 50 Ohm coaxial socket and line. Secondary into terminals for attachment of 600 Ohm load or aerial feeder with V.S.W.R. up to 1.5/1. Greater aerial imsmatches can be tolerated with a corresponding reduction in power rating.
Transformer Dissipation.	Total losses (core and copper losses) are approximately 25 watts per kW through power.
V.S.W.R. Contribution.	1.15 between 2.5 and 30 Mc/s for resistive component. 1.5 over the band for the total V.S.W.R. including the shunt reactive component which would normally be tuned out.
Balance Ratio.	The two line currents are balanced to better the 10%.
Dimensions.	Type A—Rectangular case—12½" × 9" × 7¼". Type B—Cylindrical finned cast case—15" diameter, 9" high excluding terminals.



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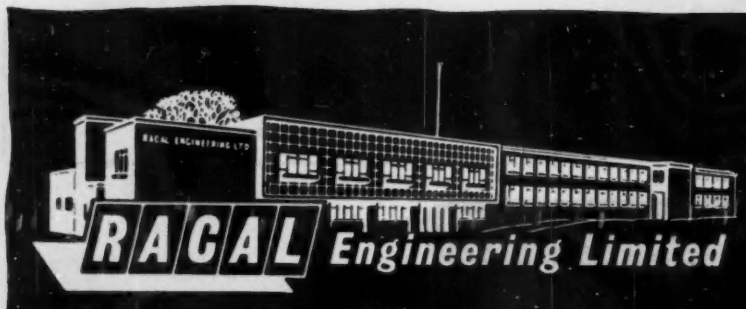

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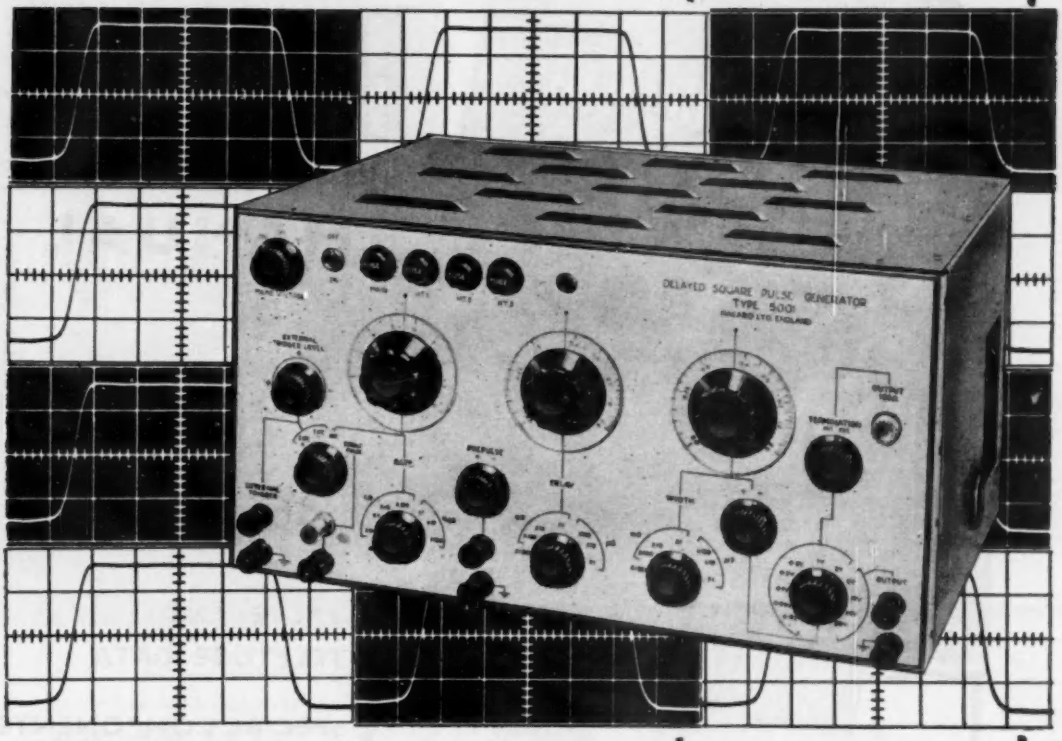

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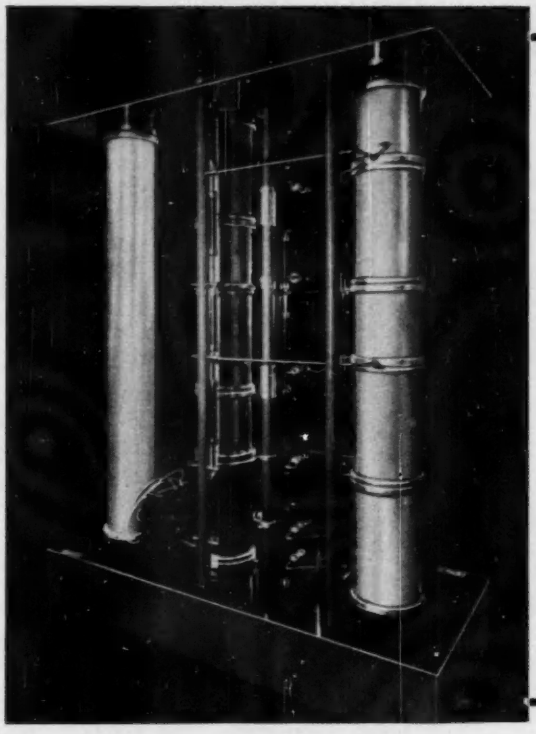

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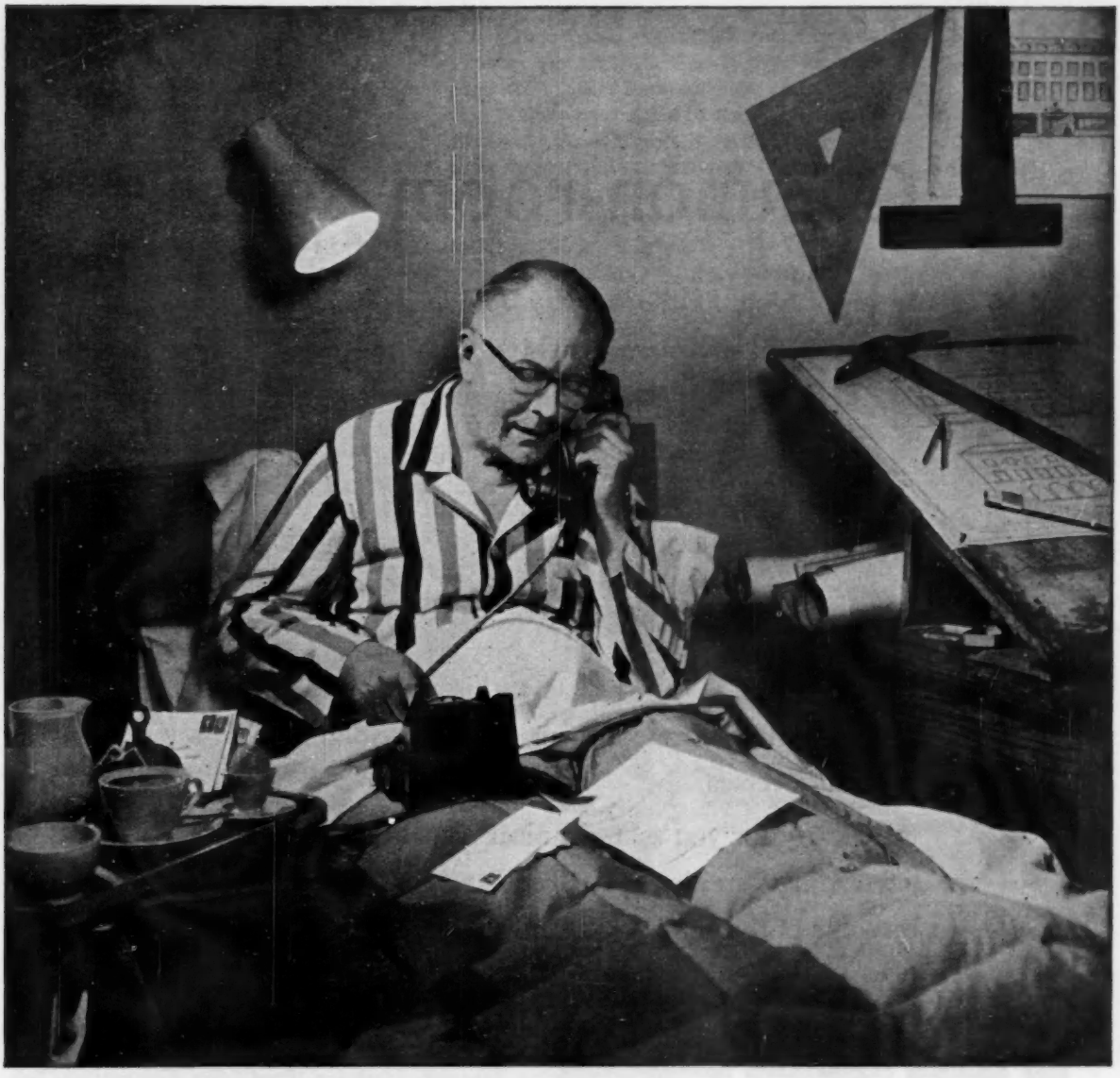

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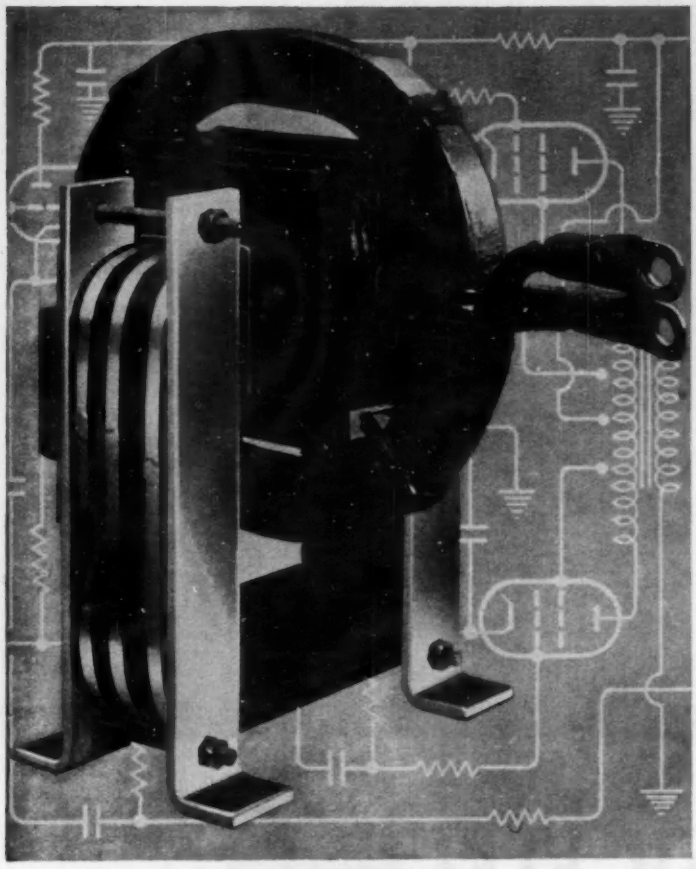

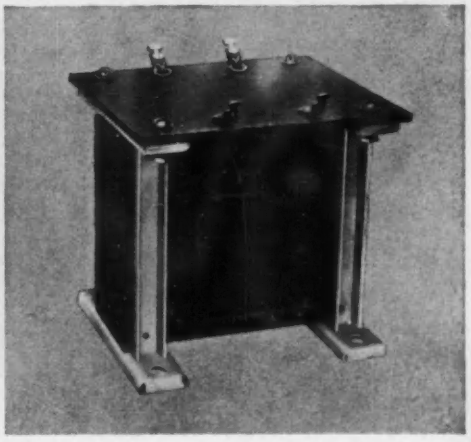

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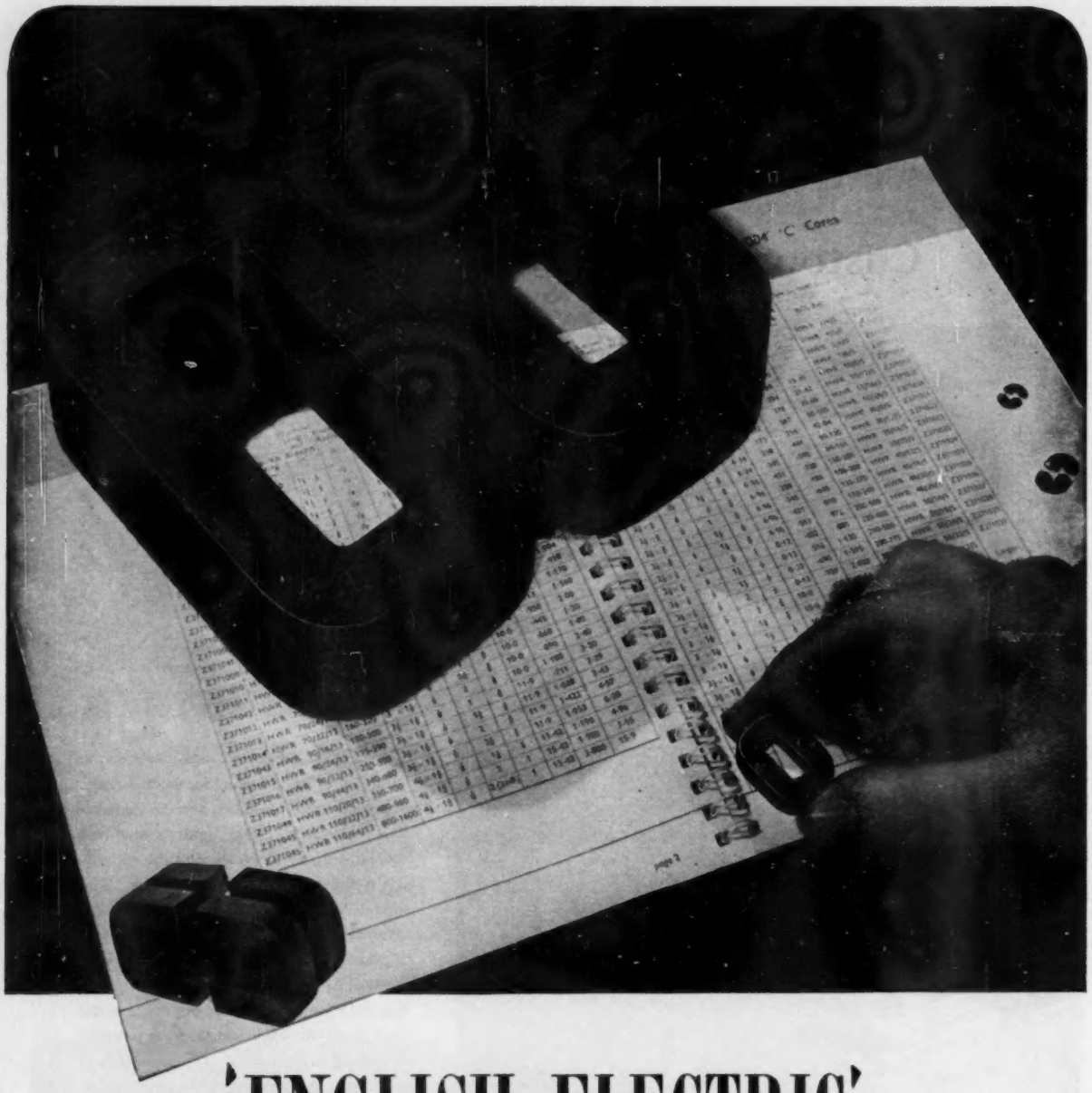

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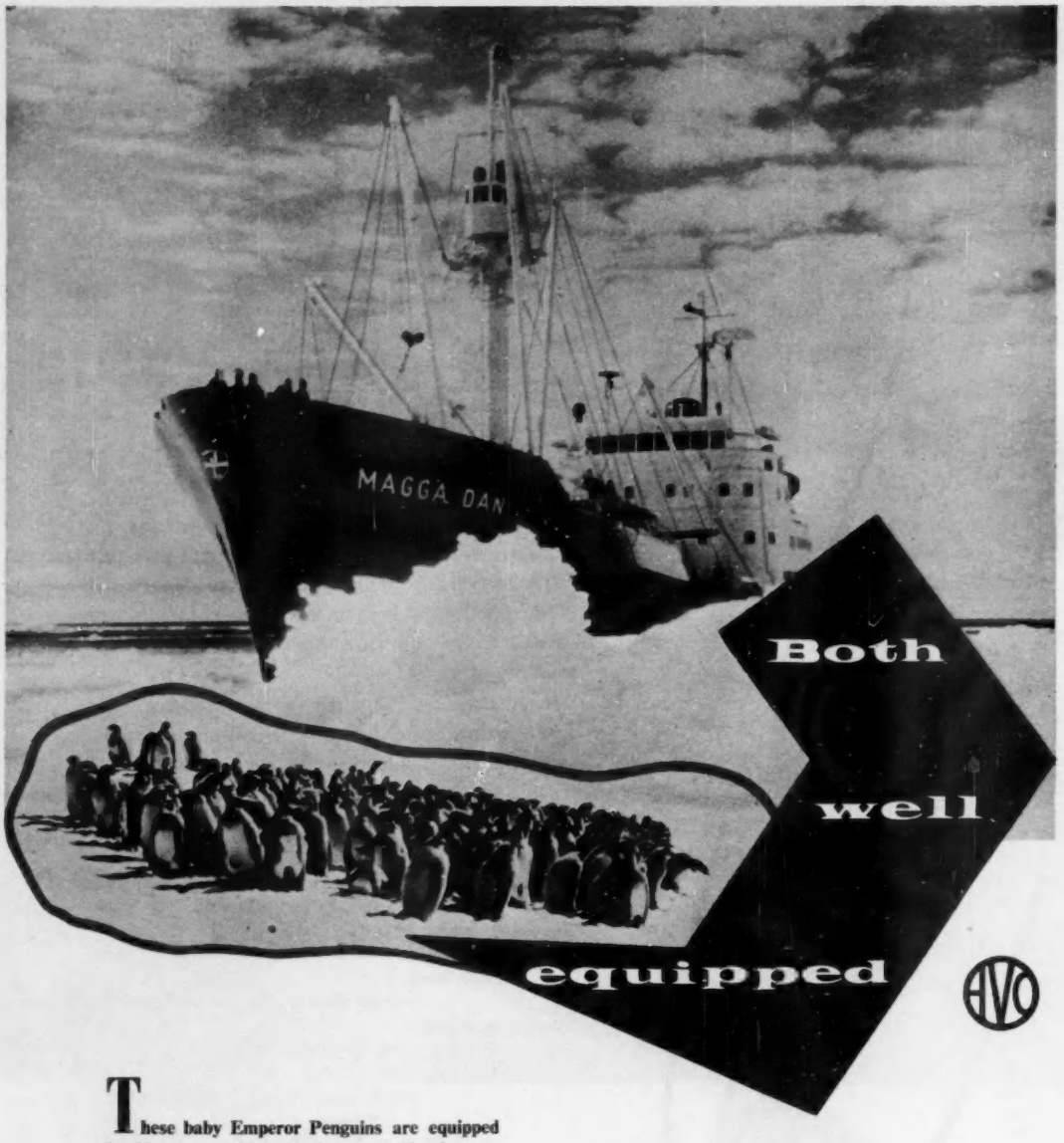

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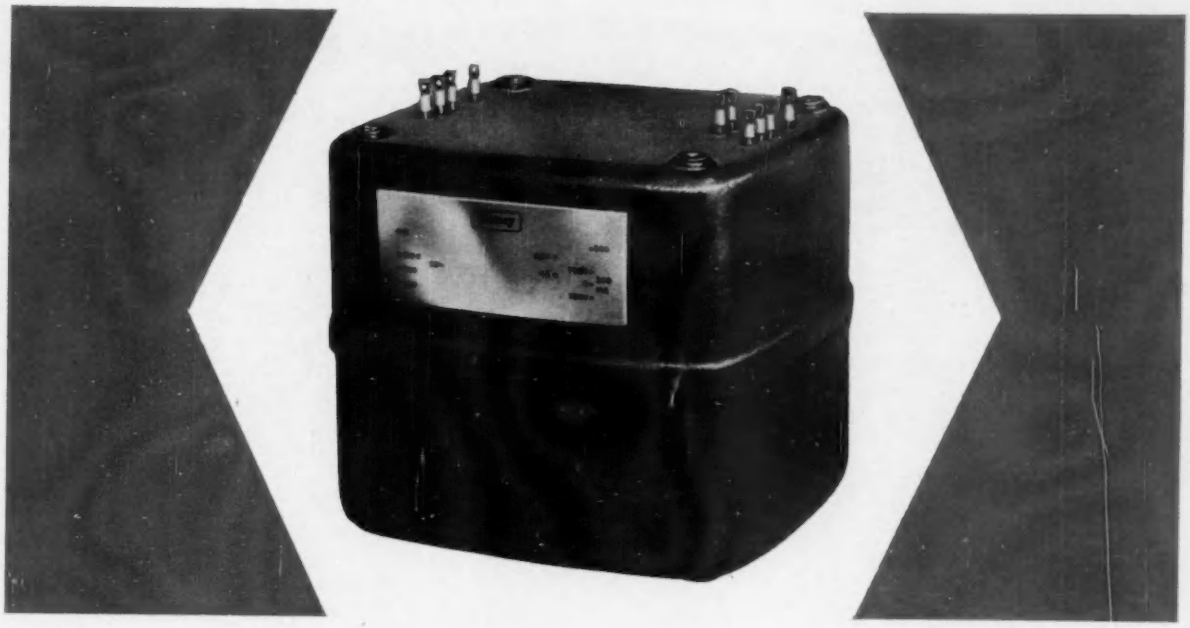

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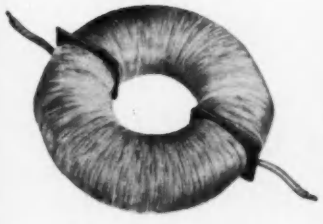
Open type 'C' Core transformer impregnated in solventless varnish to Inter-Service Specifications.



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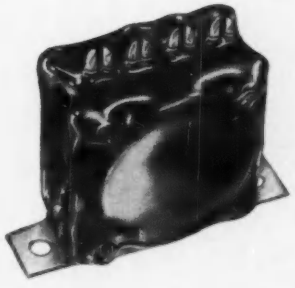

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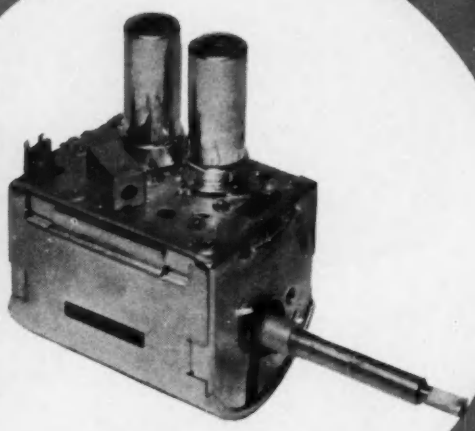

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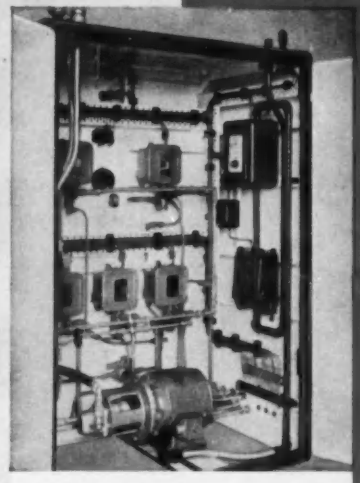

The illustration shows the inside of a Lockheed controller for a carburizing plant at Vauxhall Motors. This controls an ingenious type of conveyor, with six slave cylinders taking work pieces from the furnace to the quench tank, from which it subsequently removes them. The whole of the sequences are controlled by a Lockheed master unit and are put into action by a push-button control.

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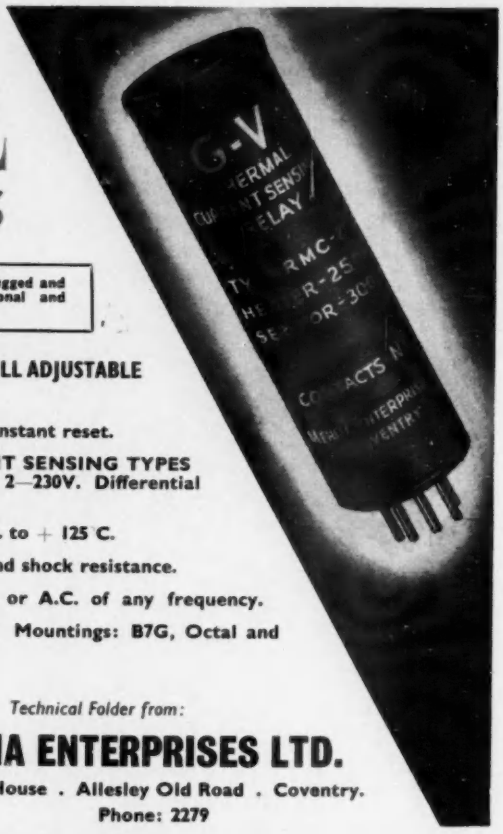

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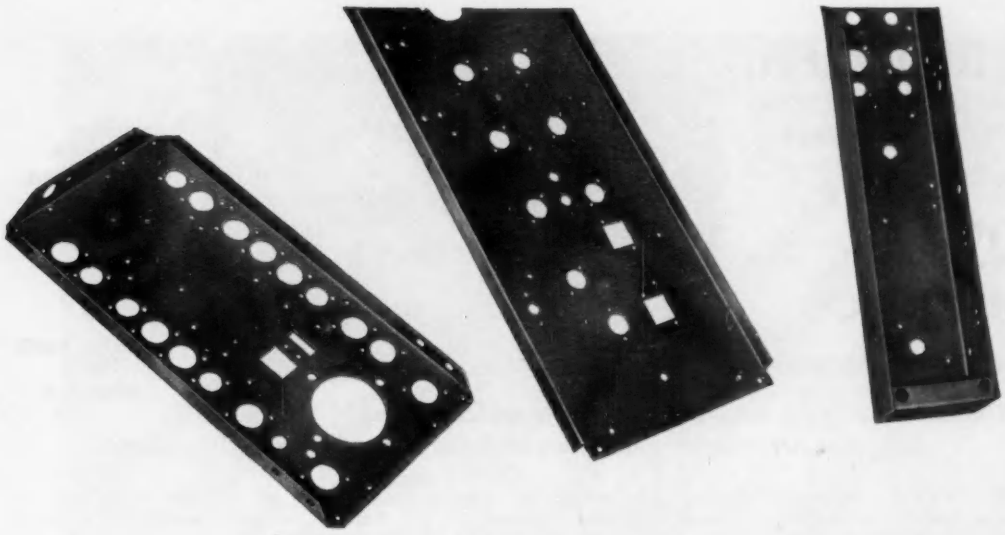

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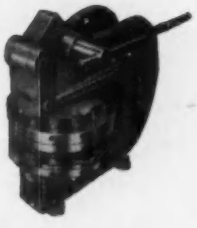

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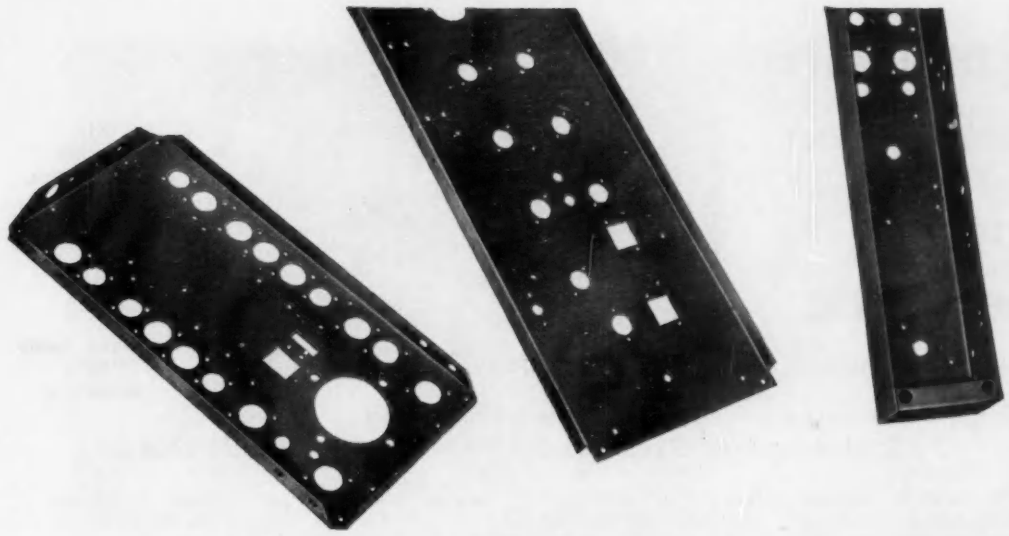

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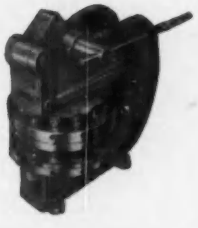

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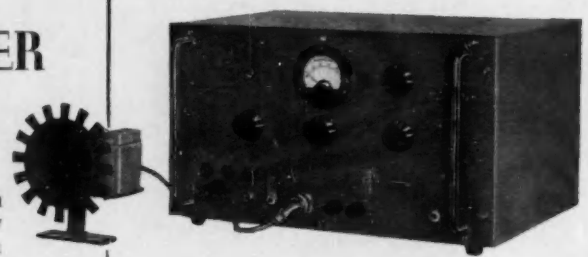

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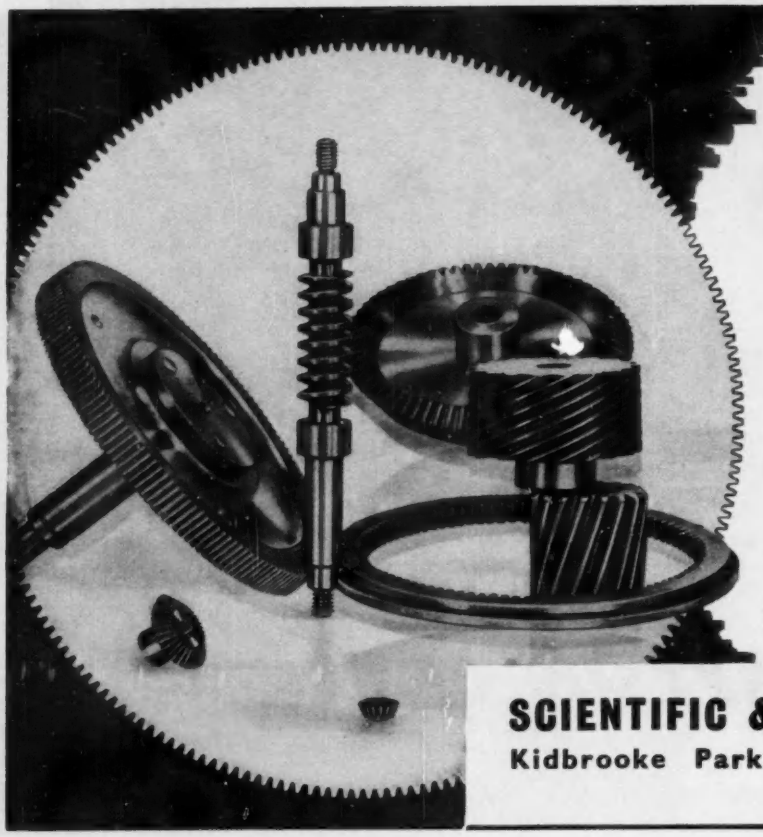

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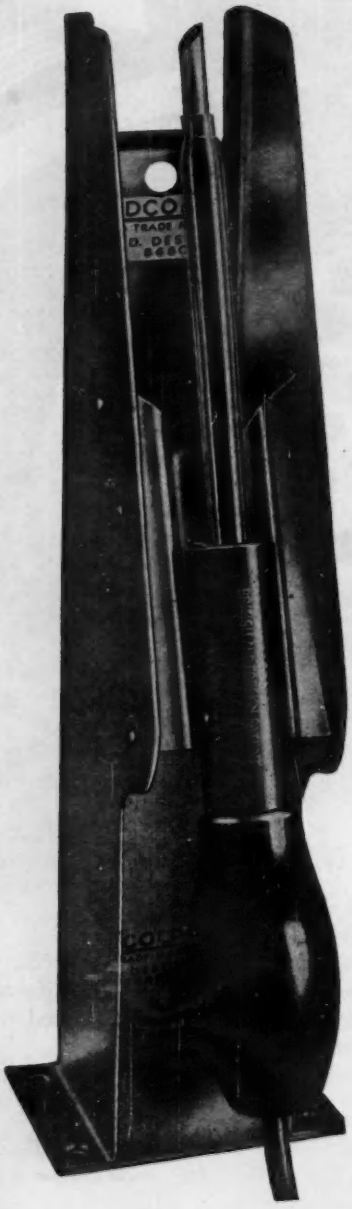

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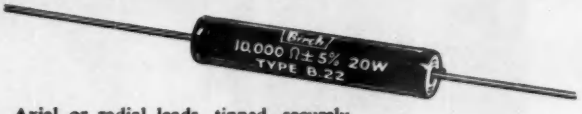

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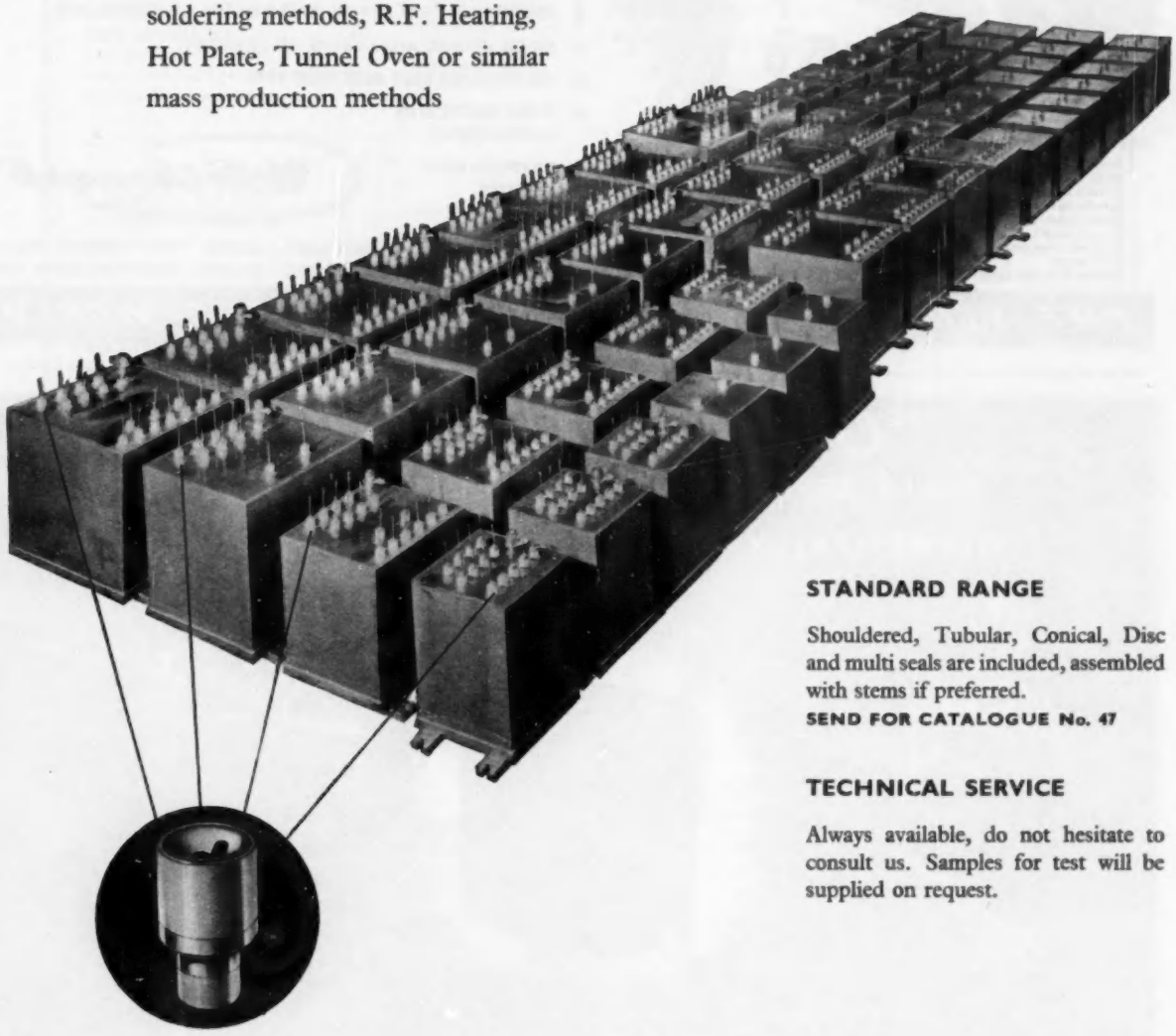

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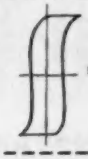

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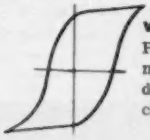

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Bimetal 15 ...	9.5×10^{-6}	16.7	20-160	—70 to 220
Bimetal 75 ...	6.8×10^{-6}	57	150-460	—70 to 550

* *The deflection constant (d) is defined as the deflection of a strip of unit length and unit thickness for each °C rise in the temperature over the linear part of the deflection curve.*

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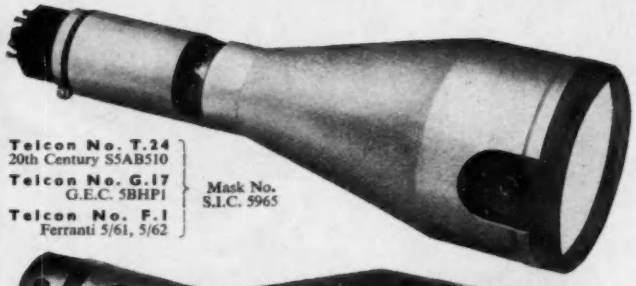

Telcon No. T.24 20th Century S5AB510
Telcon No. G.17 G.E.C. 5BHP1
Telcon No. F.1 Ferranti 5/61, 5/62
} Mask No. S.I.C. 5965

Telcon No. E.T.4 ETEL 5BKP1
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MUMETAL SHIELDS
for Cathode Ray tubes

Precision Cathode Ray Tubes demand perfect screening. Telcon's high permeability low-loss magnetic alloy MUMETAL has proved in practice to be many times more effective for this purpose than any other material of equal thickness.

The Telcon Metals Division is pleased to announce that it has now in production a standard range of MUMETAL Shields for Cathode Ray Tubes of the more popular types made by leading manufacturers such as CINEMA-TELEVISION, COSSOR, EDISON-SWAN, ELECTRONIC TUBES, G.E.C., MULLARD, 20TH CENTURY ELECTRONICS LTD. and FERRANTI. Details and drawings are available on request. Special Shields can be made to customers' specifications.

Rubber Masks are available from The Standard Insulator Co. Ltd., Camberley Surrey, for use with these Mumetal Shields.

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THE TELEGRAPH CONSTRUCTION AND MAINTENANCE CO. LTD
Metals Division, Telcon Works, Manor Royal, Crawley, Sussex. Telephone Crawley 1560

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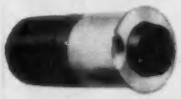
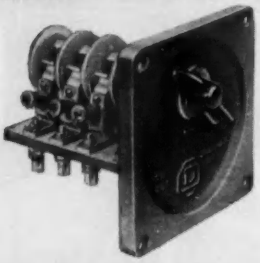


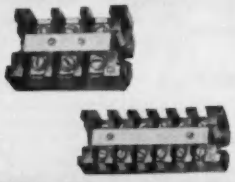
Miniature plunger, door interlock switch with N.O. contacts, 2-amps. 550-volts A.C. Size 2½" long × 1" dia. (Type C 32 L 310).

A LARGE RANGE OF



Flush-mounting T.P. isolating switch for building-in Machine Tools, etc. 30-amp. 550-volts (Type C 95).

CONTROL ACCESSORIES



Terminal blocks (Type J 96) with clamp type terminals, white marker strip. Generous clearances between phases and to earth.
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Available 2-, 4- or 8 poles (with one or two coil circuit change-over contacts), fine silver double-break main contacts rated at 10-amps. 550-volts Any pole can be N.O. or N.C.

Illustrated is a 4-pole enclosed relay (with two change-over coil circuit contacts).

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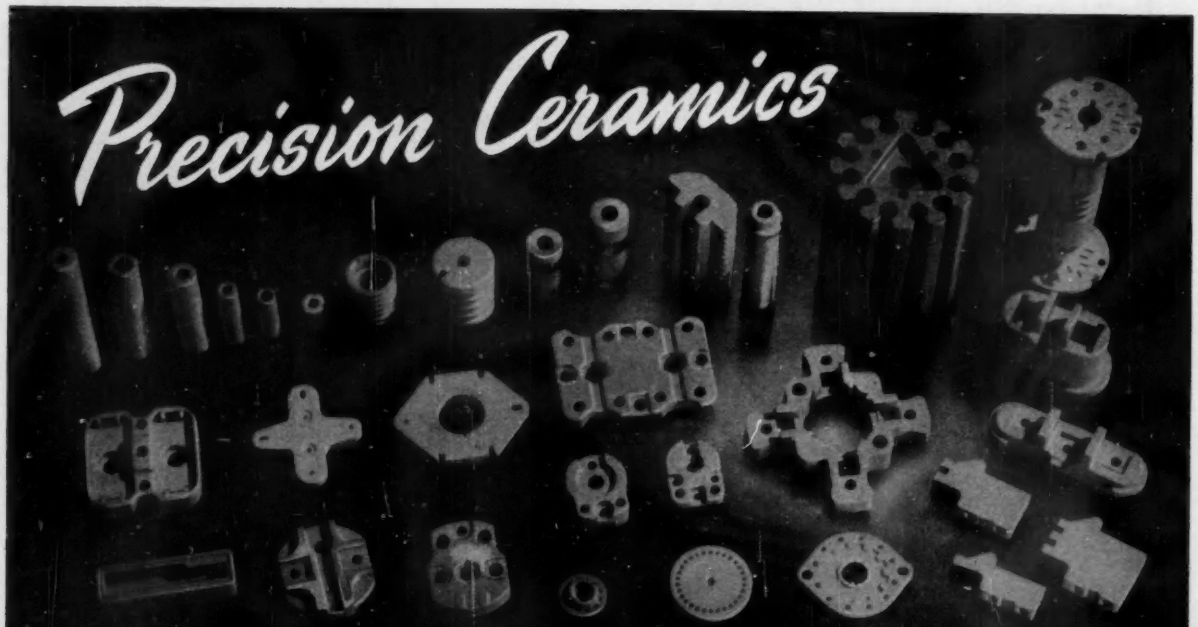

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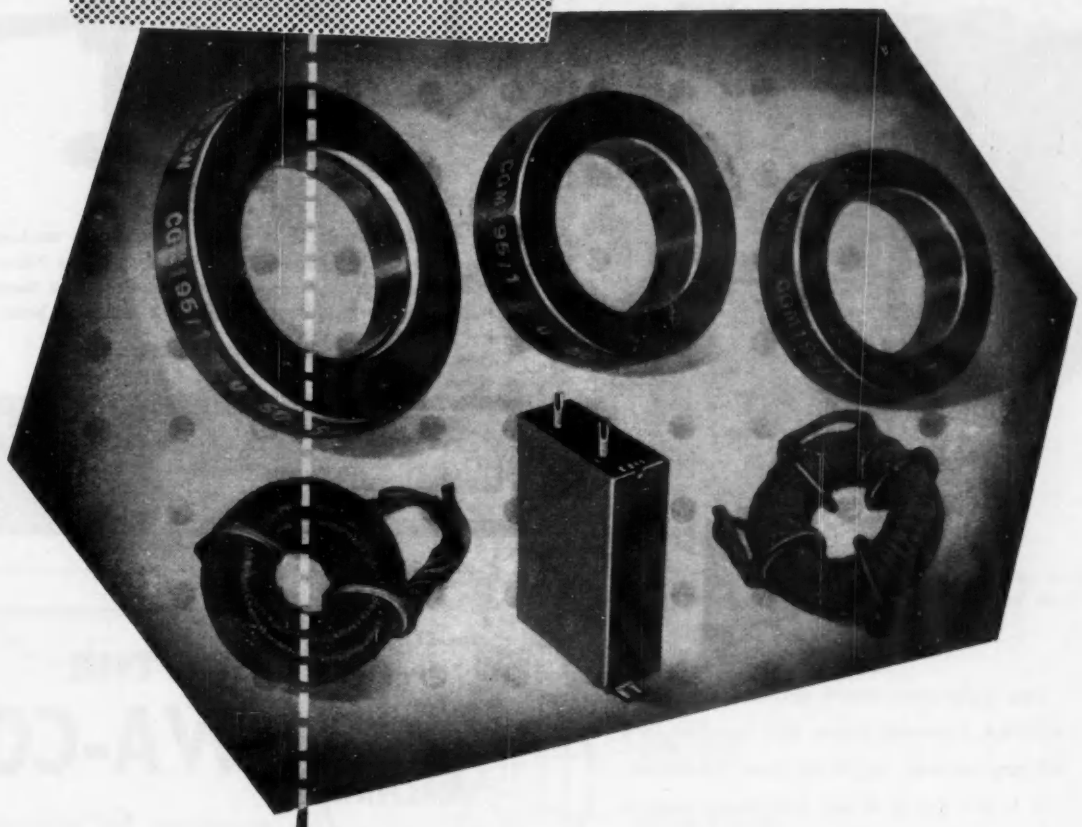

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- ★ Negligible external field
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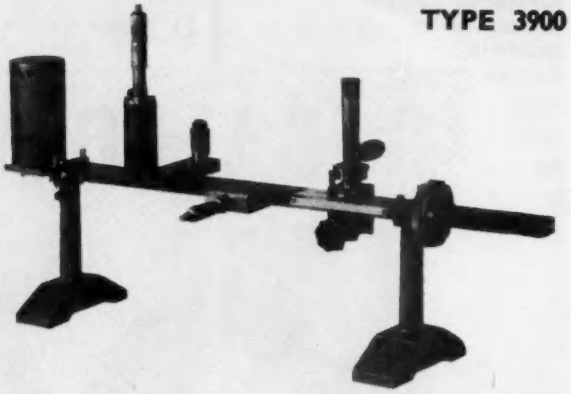

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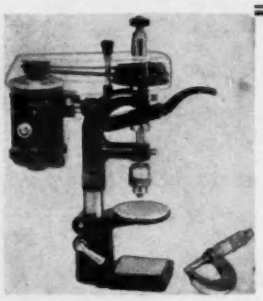

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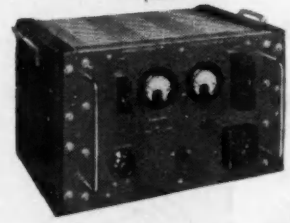
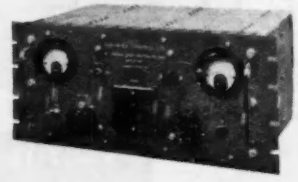


A.C.7 · 0-30 amps, Range minus 20% to plus 10%. 12 volts per second.



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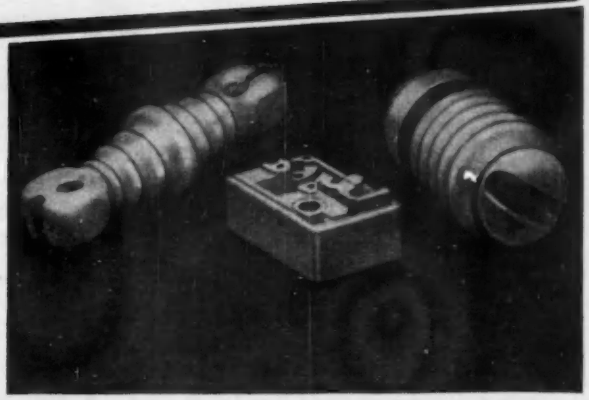

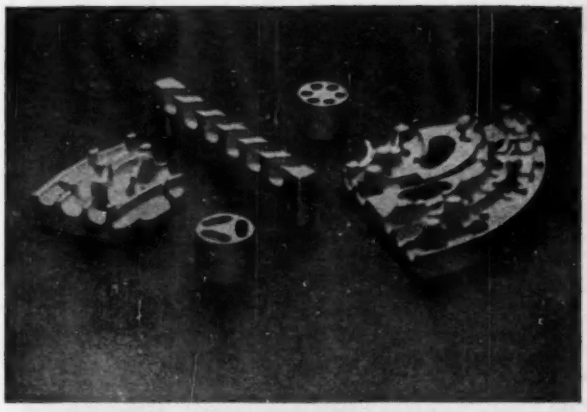

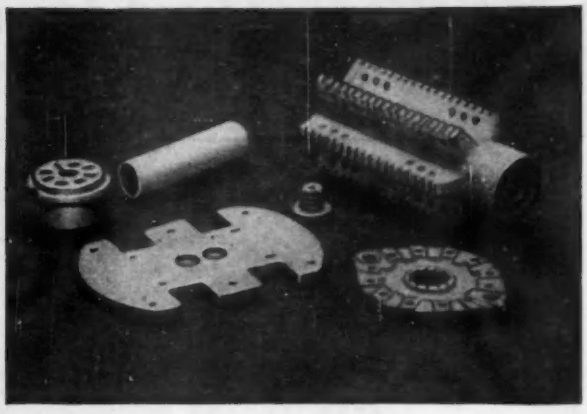

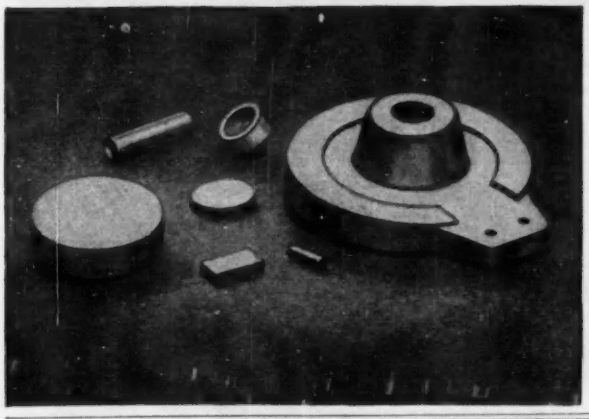

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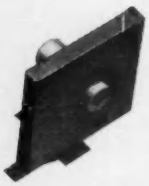
To illustrate the extreme hardness of SINTOX Industrial Ceramic, the photograph on the right shows a ¼" diameter tube of SINTOX which, without even chipping, was forced through a ¼" thick mild steel plate.



SINTOX IN THE ELECTRICAL INDUSTRY

Compared to porcelain, in tension, compression and cross breaking, SINTOX has at least twice the strength; and insulating properties twice as good.

Electrical resistance—SINTOX is so little affected by temperatures that at 300°c. it is about one million times that of of porcelain. Thermal conductivity twenty times better than porcelain—almost comparable with steel.

SINTOX has already many applications in the electronics field. For instance, for formers in place of traditional wire-wound resistors and in the repeaters used for the Trans-Atlantic cable. Other applications in the electrical industry are legion.

THE HARD CERAMIC **SINTOX**

STAS

Sintox Technical Advisory Service

This service is freely available without obligation to those requiring technical advice on the application of Sintox Industrial Ceramics. Please write for booklet or any information required enclosing blue print if available.

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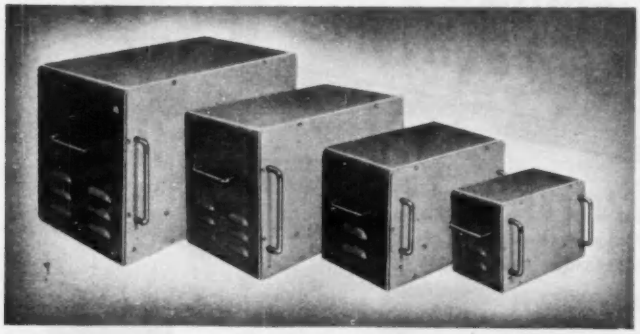
QUALITY *backed by experience*



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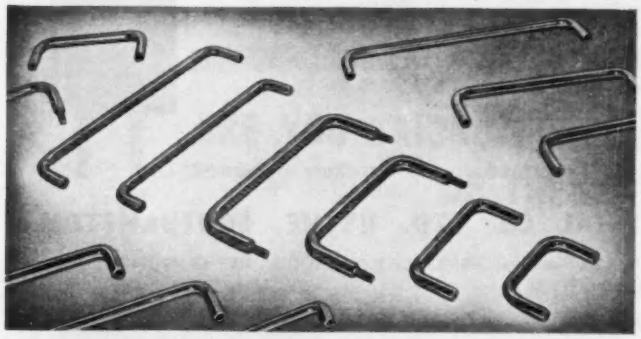

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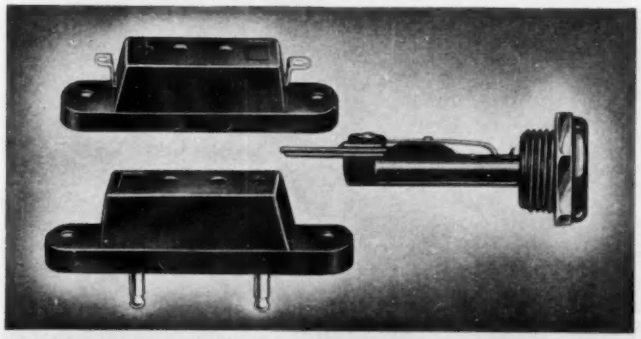
Made in standard range (4 in., 6 in., 8 in. and 10 in. centres). A wide variety of other sizes can be made to special order.



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Invaluable device designed to facilitate current measurements. Installed in series with an electrical (or electronic) circuit to all points where measurements or checks are required without open circuiting.

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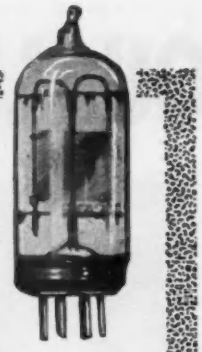

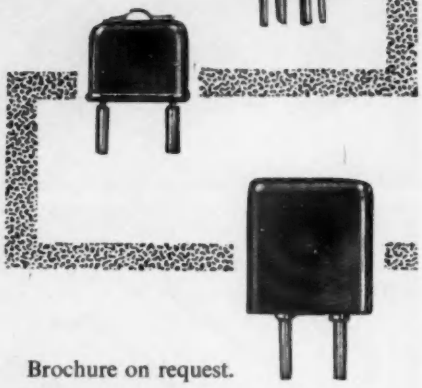

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(The diagram shows information required when ordering this type of spring.)

RB FAMOUS FOR SPRINGS SINCE 1921

There are no finer springs than Springs by **Riley**

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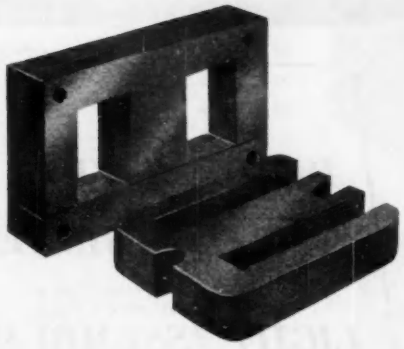

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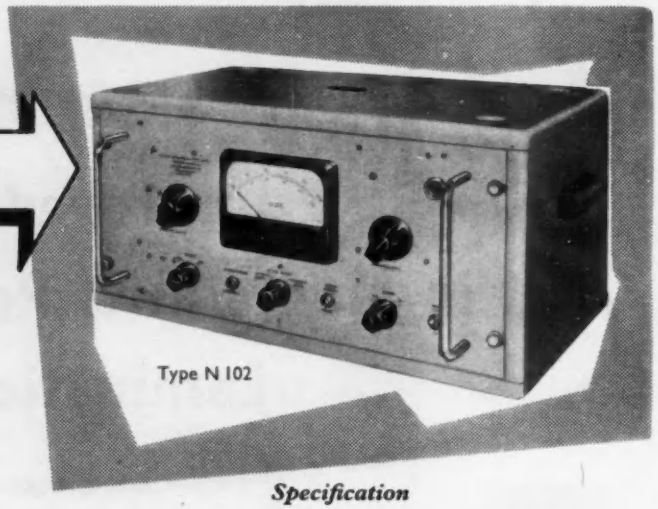
The Dynatron Scanning Pulse Amplitude Analyser, Type N 102, is an ideal instrument for use in Gamma Spectrometry, and is highly suitable for use with scintillation counters. A toggle switch on the front panel enables the N 102 to be converted into a simple discriminator.
The output of the Analyser may be fed to a Scaling Unit or a Ratemeter. Should a Ratemeter be used, its output can be fed into a chart recorder with suitable sensitivity and chart-speed facilities, and a continuous spectrum analysis obtained.



Specification

Input: Positive.

Length: 0.5 μsec. Minimum.

Amplitude: Range of measurement, 5-50v. and 5-100v.

Sweep Speed: 1v./min. 50v. range; 2v/min. 100v. range.

Stability of Threshold: 0.1v.

Channel Width: Variable 0-10v. or 0-50v. Stability ±1%. Accuracy ±2%.

Output Pulse: Positive. Amplitude on open circuit 20v.

Resolving Time: Less than 1 μsec.

Accuracy in Pulse Height: ±2%.

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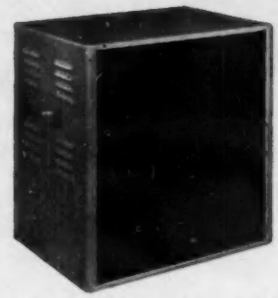
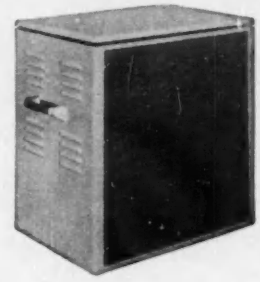
1024 IN THREE SIZES

	Width	Depth	Height	Weight
1024A	21⅛"	15⅜"	11⅛"	35 lbs
1024C	21⅛"	15⅜"	22⅛"	43 lbs
1024D	21⅛"	15⅜"	32⅛"	53 lbs



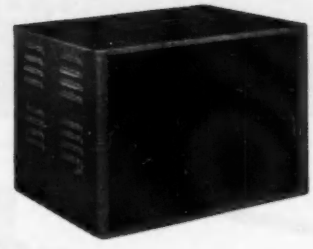
1034 IN THREE SIZES

	Width	Depth	Height	Weight
1034A	21⅛"	15⅜"	11⅛"	41 lbs
1034C	21⅛"	15⅜"	22⅛"	48 lbs
1034D	21⅛"	15⅜"	32⅛"	59 lbs



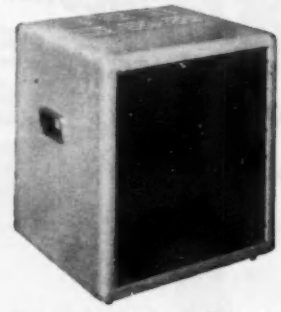
1028 IN THREE SIZES

	Width	Depth	Height	Weight
1028A	17½"	15⅜"	10½"	21 lbs
1028B	19½"	15⅜"	11½"	25 lbs
1028C	26½"	15⅜"	16½"	31 lbs



1065 IN THREE SIZES

	Width	Depth	Height	Weight
1065A	22½"	20½"	14"	47 lbs
1065C	22½"	20½"	24½"	58 lbs
1065D	22½"	20½"	35"	90 lbs



1063 IN THREE SIZES

	Width	Depth	Height	Weight
1063A	16½"	8½"	9"	18½ lbs
1063B	20"	8½"	9"	21½ lbs
1063C	16½"	14"	9"	26½ lbs

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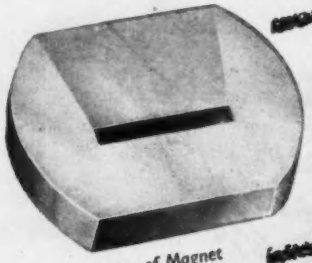

Actual size of Magnet

Photograph by courtesy of Higrade Instruments

The instrument illustrated is 0/5 μA. F.S.D. with terminal resistance of 2,000 Ω. Another example of the use of Murex "Sincomax" magnets where a high energy product with high magnetic stability is essential.
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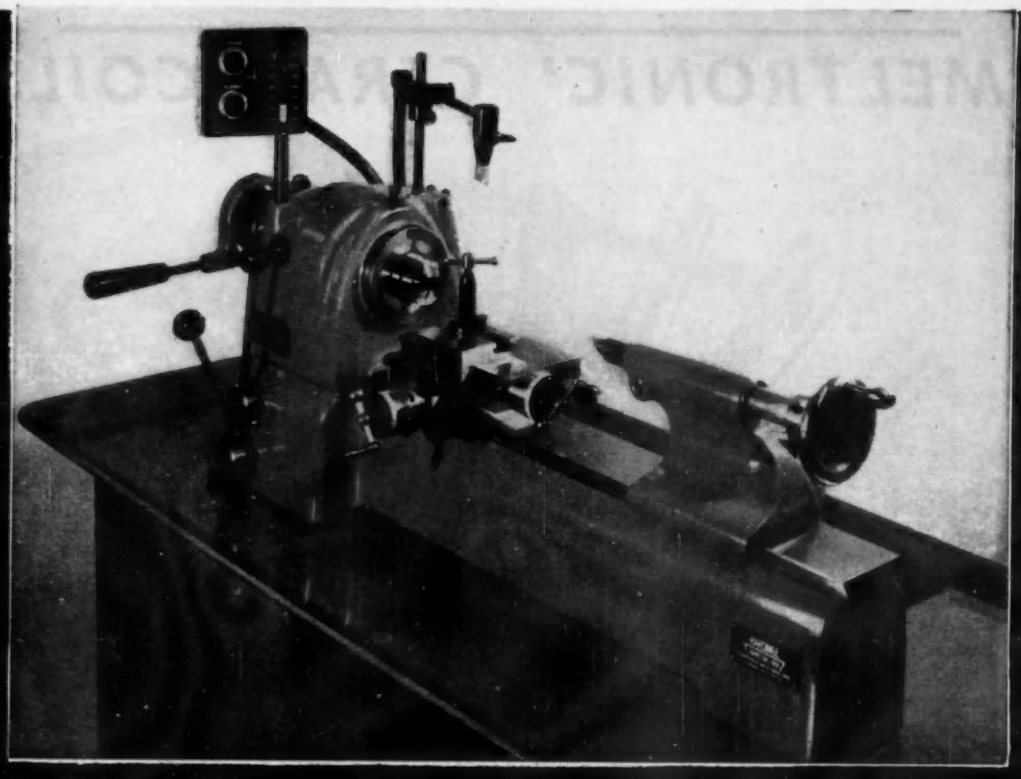

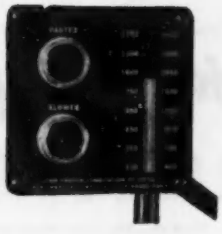

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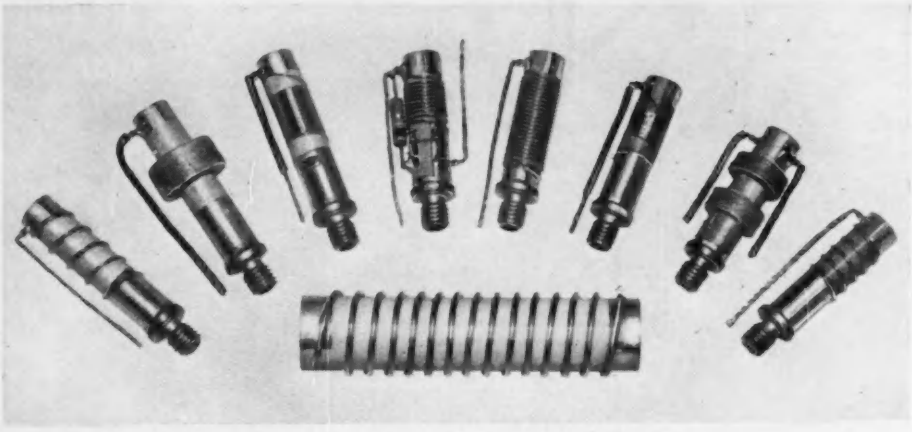

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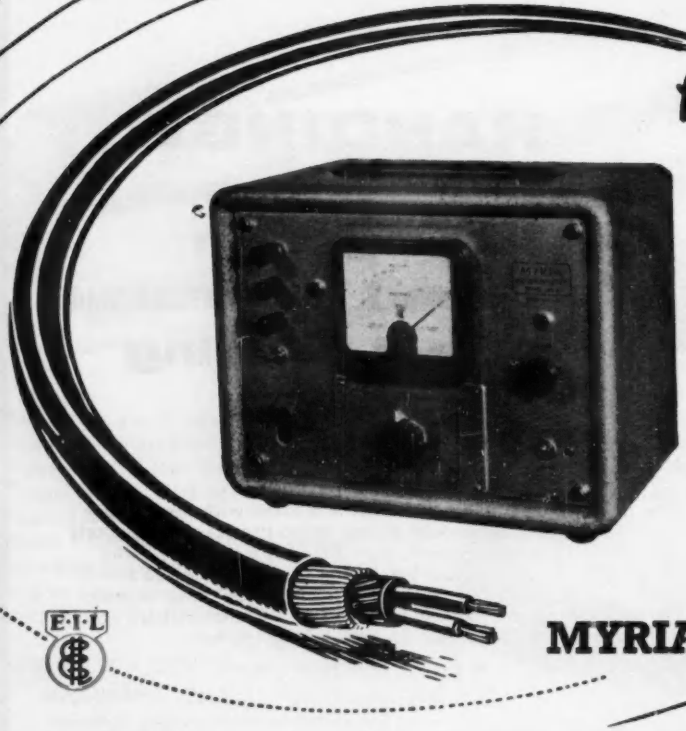

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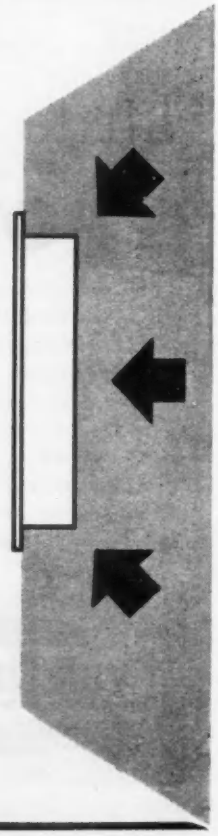

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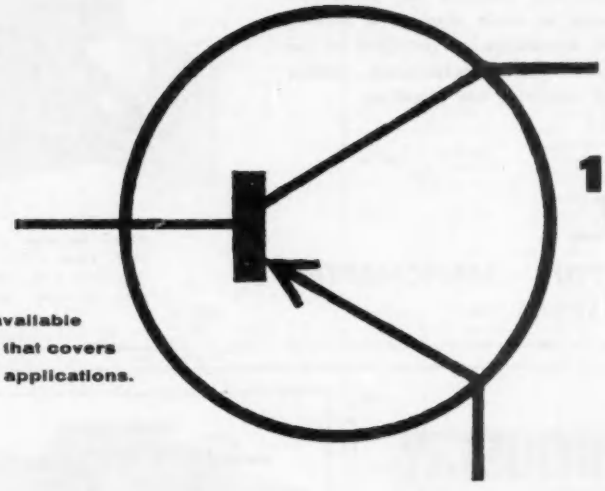

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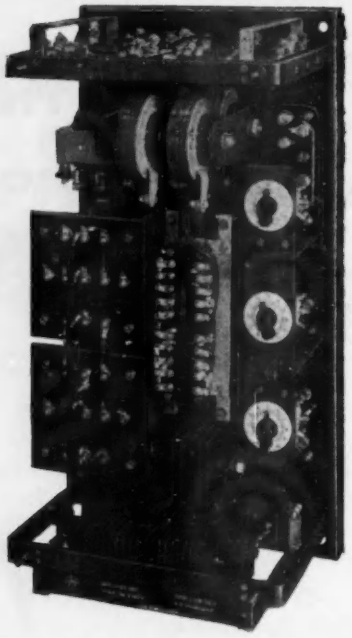

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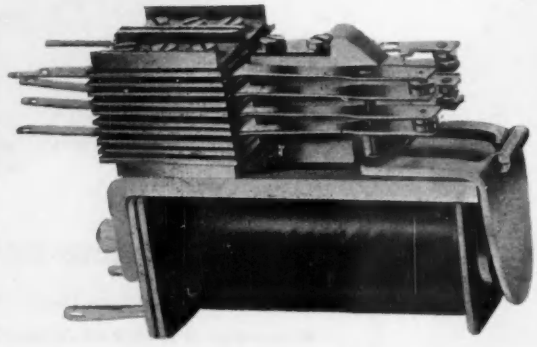

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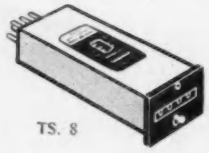
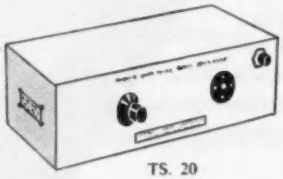
TRANSISTORIZED PLUG-IN STAGES FOR HIGH-SPEED COUNTING



TS. 8

TS. 5

TS. 2A. 2B

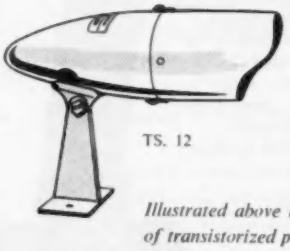


TS. 20

TS. 10. 11

TS. 1. 4. 7. 14. 16. 18. 19

TS. 3. 6. 17



TS. 12

TS. 9. 13

Illustrated above is the Venner range of transistorized plug-in stages shown approximately ¼ of their actual size. Write for Brochure EE/104.

TABLE OF VENNER TRANSISTORIZED STAGES			
Reference	Name of Stage	Function of Stage	To Drive
TS1	1000 c/s Oscillator	Stable frequency source of ±1% tolerance. Sine wave and square-wave output.	TS3, 4, 6, 7, 14, 16, 17.
TS2A TS2B	Binary Unit	Provides one output pulse for two input pulses at PRF's up to 30 K.p.p.s.	TS2, 7 to 11, 13, 14, 16, 17, 18.
TS3	Wide Band Amplifier	Amplifies input voltage by a factor of approx. 1000 over a freq. range of 15 c/s to 125 kc/s.	TS2, 3, 4, 7, 8, 10, 11, 13, 14, 16, 17.
TS4	2-stage Amplifier	Amplifies input voltage by a factor of 1000 over a frequency range of 120 c/s to 10 Kc/s.	TS2, 4, 7, 8, 10, 11 13, 14, 16, 17.
TS5	10 kc/s Crystal Osc.	Ultra-stable frequency source with an accuracy of 3 parts/million. Sine and squarewave outputs.	TS2, 3, 6, 7, 10, 11, 14, 15, 16, 17.
TS6	Selector Gate	Schmitt trigger circuit. Basically intended for use with TS11.	TS2, 6, 8, 9, 10, 11, 13, 16, 17, 18.
TS7	Shaping Amplifier	Converts input waveforms into pulses suitable for triggering the Binary and Decade stages.	TS2, 8, 10, 11, 13, 16, 18.
TS8	Cyclo Counter	Transistorized Electro-mechanical Counter which ensures correct operation irrespective of duration of input pulse.	May be used to reset TS2, 10, 11.
TS9	D.C. Relay Stage	Permits 5A, 250V change-over contacts to be operated from a 100 micro A source.	May be used to reset TS2, 10, 11.
TS10/5	Decade Counter	Divide-by-ten or Divide-by-five stage, divides and counts inputs up to 30 K.p.p.s.	TS2, 8 to 11, 13, 16 to 18.
TS11	Decade Selector	Used in conjunction with 10 position switch and TS6 unit permits selection of any pulse 0–9.	TS2, 6, 8, 9, 10, 11, 13, 16, 17, 18.
TS12	Photohead	Sensitive photo-transistorized head for universal use. Direct coupled, anti-phase outputs.	TS3, 4, 6, 7, 8, 9, 13, 14, 16, 17, 18.
TS13	Triggered Relay Stage	Ensures 0.05 second operation of 5A 250V changeover contacts when pulsed.	May be used to reset TS2, 10, 11.
TS14	Pulse Shaper	Provides constant amplitude antiphase pulses for all inputs. Ideal for triggering binary and decade stages.	TS2, 8, 10, 11, 13, 16, 18.
TS16	Universal Gate	Unity gain stage which can be switched ON and OFF by D.C. level change as provided, for example, by TS2B.	TS2, 3, 4, 8, 10, 11, 13, 15, 17, 18.
TS17	Twin Emitter Follower	Two separate high input impedance stages with low output impedances. Equivalent to cathode follower.	TS2, 3, 4, 6, 7 to 11, 13 to 18.
TS18	Period Timer	Provides D.C. voltage change for externally adjustable period. (Fixed internal period is 10 secs.)	TS2, 6, 8 to 11, 13, 16, 18.
TS20	Stabilized Power Supply	Provides 8–12V D.C. (Adjustable) at 300 mA when fed from 200/250V 50 c/s mains.	All stages.

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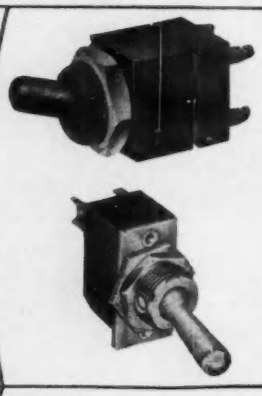

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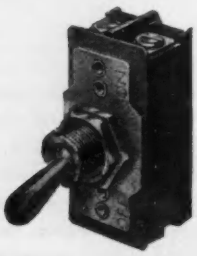

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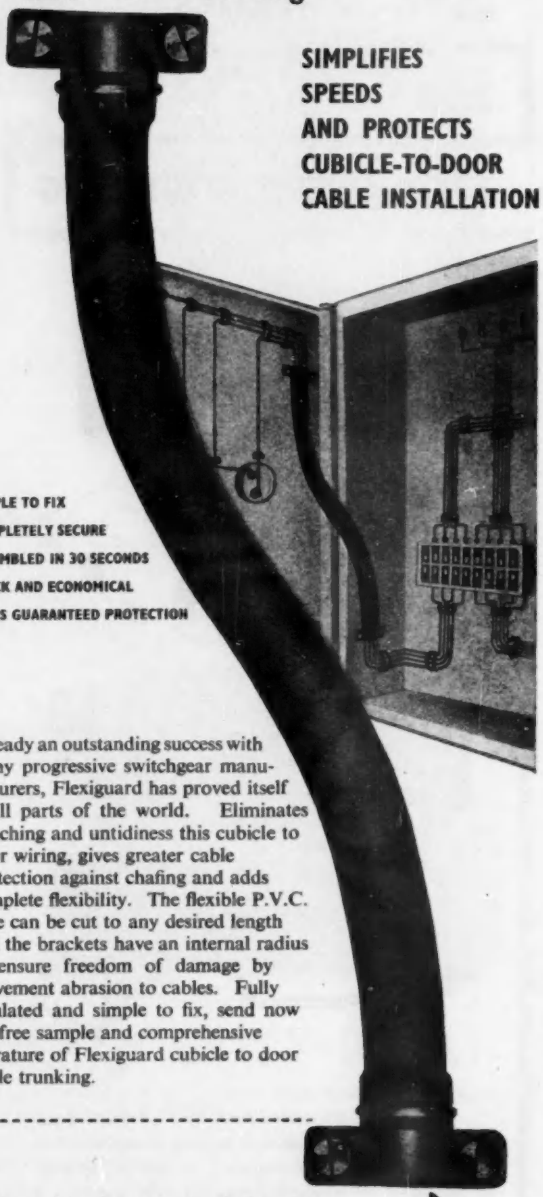

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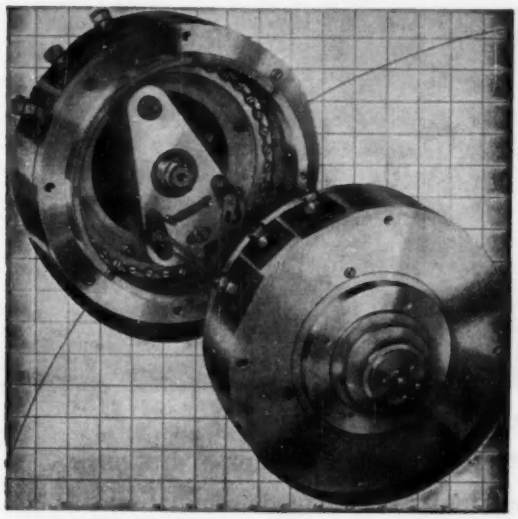

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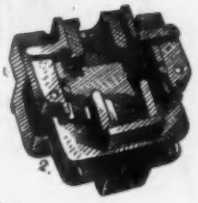

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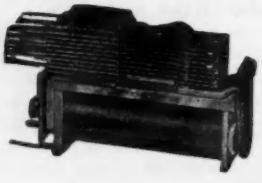

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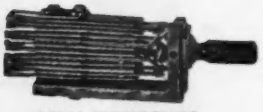

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TYPE No. 532A

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For use with Geiger Muller tubes, proportional counters, and scintillation counters

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Range 1. Guaranteed current from 7 mA at 300V to 5 mA at 700V
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STABILITY:
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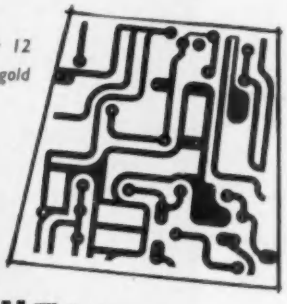

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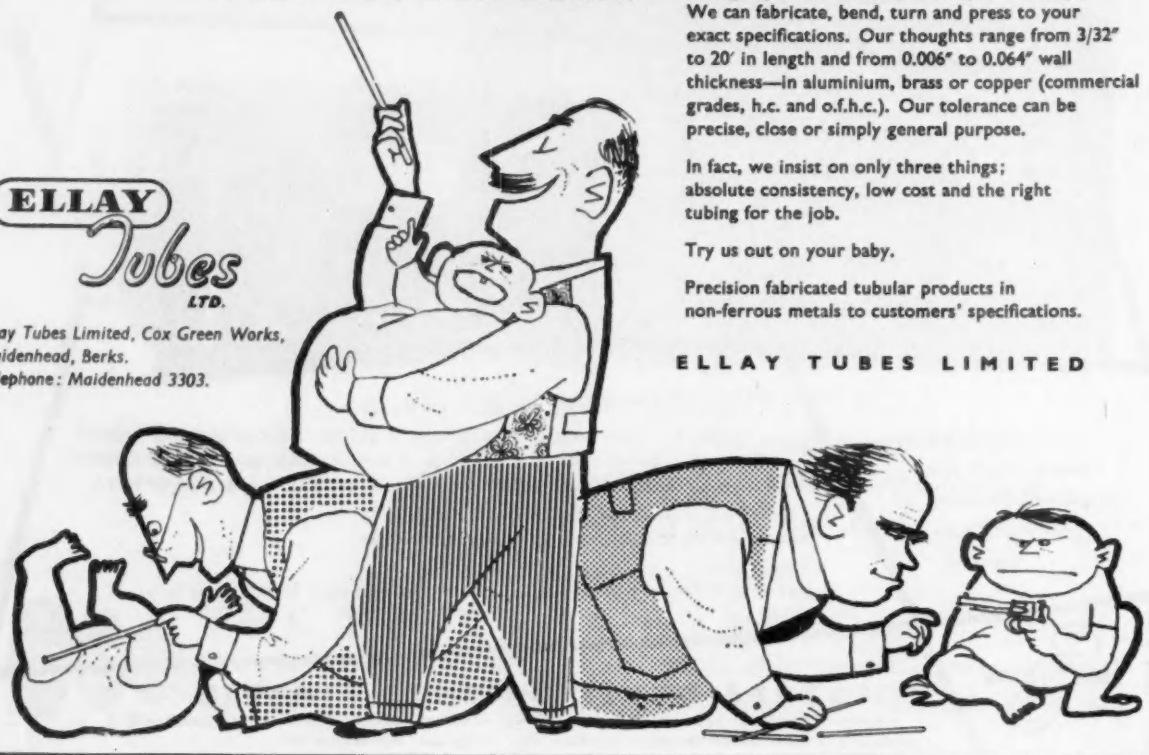

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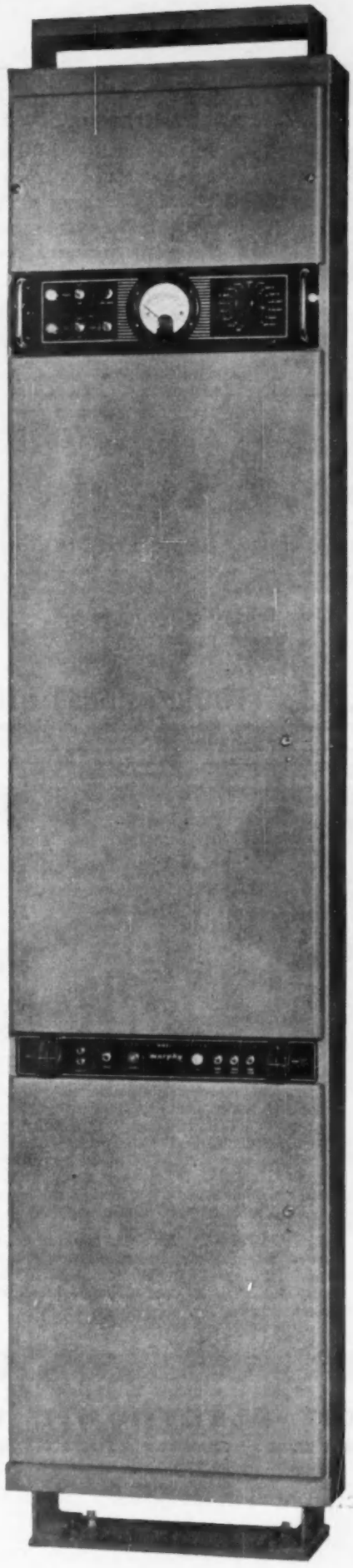
24 Channel trunk radio system, MR 851



It provides a frequency modulated trunk radio system for 24 channels when used with normal channelling equipment. This unit is designed for use where cables are impracticable or too costly. Further units may be added as repeaters to increase path length, the number being limited only by the final signal/noise ratio. Repeaters are non-demodulating and there are special frequency control arrangements which prevent cumulative crystal errors from arising in multi-unit systems. There is a 'party line' engineering channel meter panel and an automatic fault alarm. Automatic change-over facilities are available. Units are normally equipped with multi-element antenna and air-spaced co-axial feeders which may be gas filled.

We shall be happy to send you detailed technical data on the unit illustrated.

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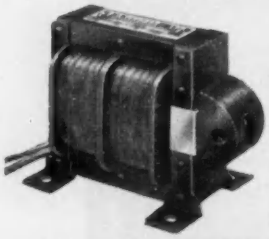

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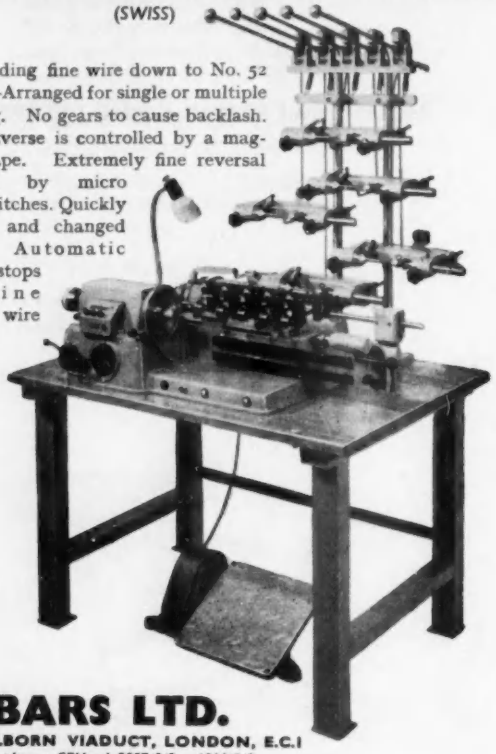

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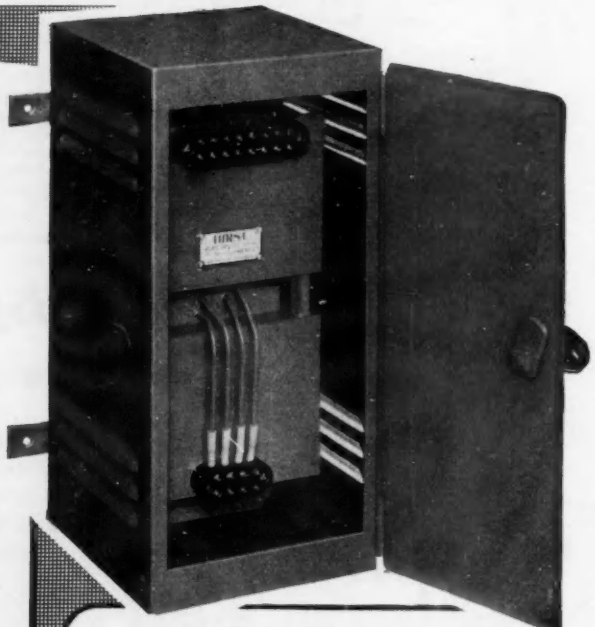

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High Frequency Cables

Aeraxial cables have a unique five-air cell construction which provides a high ratio of air to Polythene insulation—resulting in lower losses, particularly at higher frequencies.

AERAXIAL (CAT. No. 597)

Specification

Conductor ...	7/·010 in.
Polythene Dia. ...	·123 in.
Braid	·006 in.
Dia. over braid ...	·147 in.
Overall dia. ...	·210 in.
Sheathing colour	Brown

Electrical Characteristics

Characteristic Impedance	66-77 ohms
ATTENUATION db/100 ft. at 45Mc/s ...	2·3
at 60Mc/s ...	2·6
at 200Mc/s ...	5·0
Capacitance pF/ft.	18pF
Power handling capacity 200Mc/s	80 watts
Velocity ratio V/C	·74

Catalogue No. 598—As Catalogue No. 597, but with 1/.029 solid conductor. Other details as Catalogue No. 597.

SUPER AERAXIAL (CAT. No .499)

Specification

Conductor ...	1/·048 in.
Polythene dia. ...	·195 in.
Braid	·006 in.
Dia. over braid	·219 in.
Overall dia. ...	·275 in.
Sheathing Colour	Brown

Electrical Characteristics

Characteristic Impedance	66-77 ohms
ATTENUATION db/100 ft. at 45Mc/s ...	1·2
at 60Mc/s ...	1·5
at 200Mc/s ...	3·0
Capacitance pF/ft.	18·0pF
Power handling capacity 200Mc/s	300 watts
Velocity ratio V/C	·75

This type supersedes the previous Catalogue No. 499 Coaxial. Flat Twin Feeders are also available.

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Double Screened Aeraxial (Cat. 625).—Supplied with a 1/048 high conductivity annealed copper conductor. The electrical characteristics as Super Aeraxial (Cat. 499).

Aeraxial for Overhead Suspension (Cat. 626).—With a 1/048 galvanized steel catenary wire as an integral part of the P.V.C. sheath, the specification and electrical characteristics are the same as for Aeraxial (Cat. 597).

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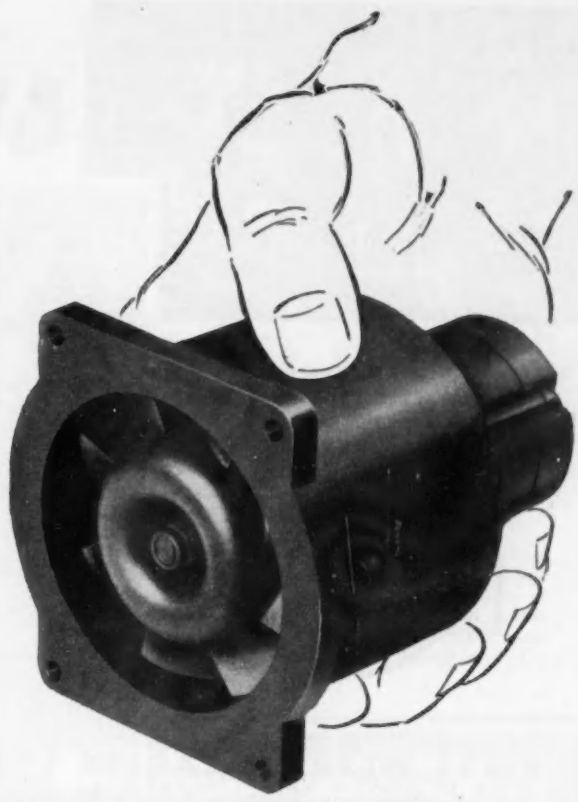
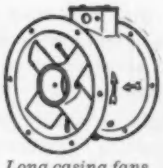


A selection of precision fans

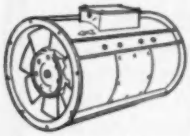
A variety of fans for electronic equipment are detailed in Woods small fan catalogue V3695, just out. Included amongst them is the 2.4 in., 400 c.p.s. fan above. Running at 11,000 r.p.m., it develops 1 in. w.g.; weighs under 1 lb.

May we send you the new catalogue?

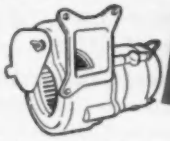
Short casing axial fans 4¼", 6", 12".



Long casing fans 6", 7¼", 8½", 12".



Two stage axial from 7¼" upwards.



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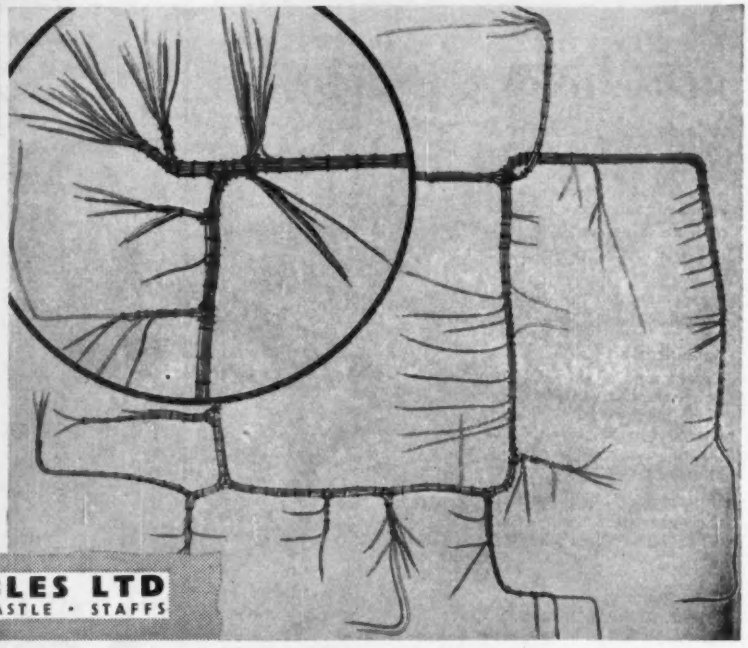

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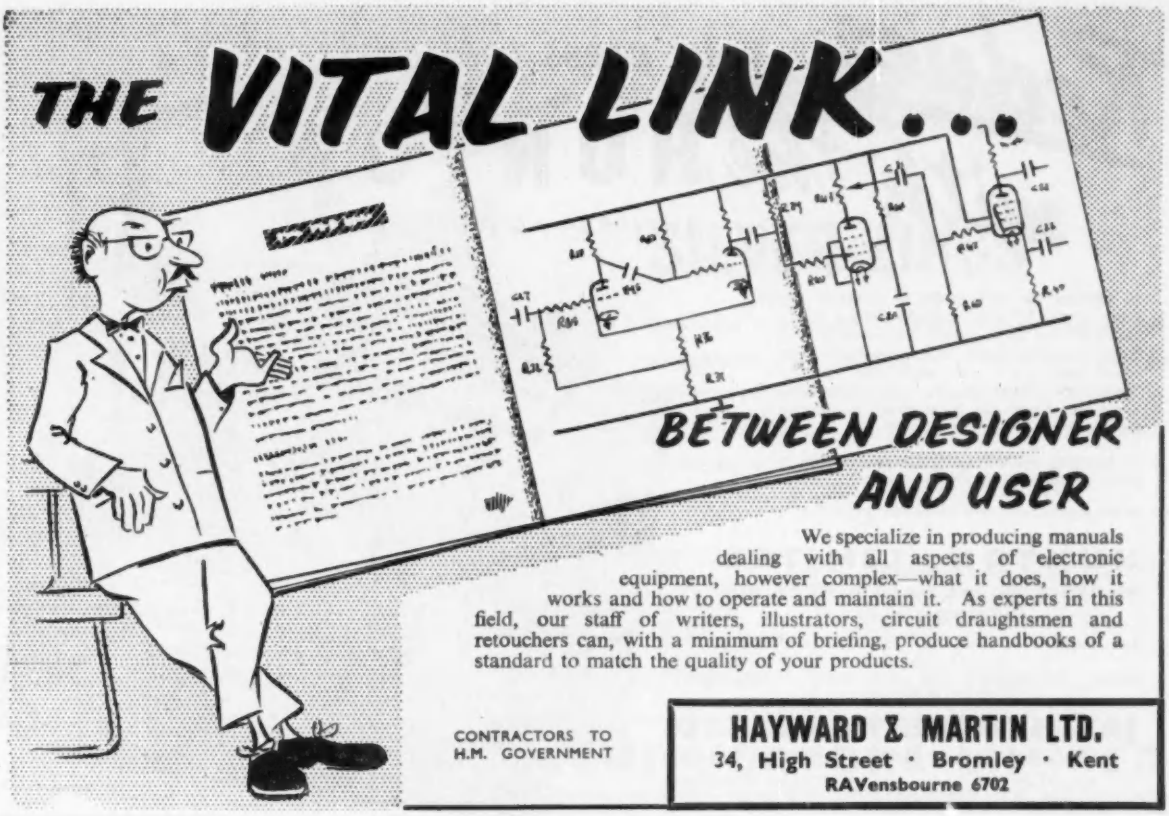

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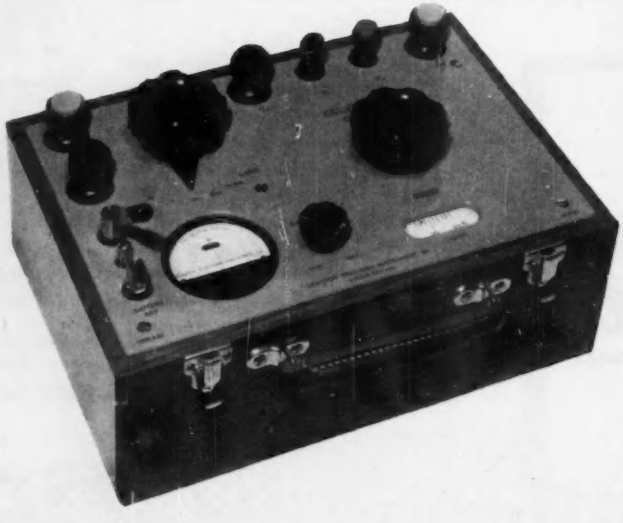
KELVIN BRIDGE OHMETER - *Type K.B.1*



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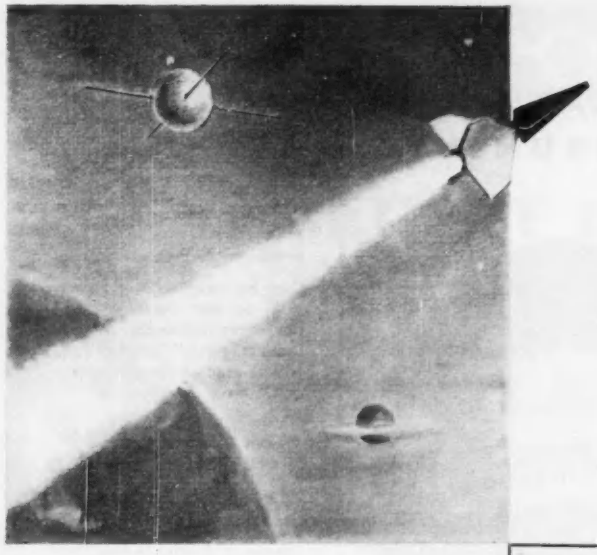

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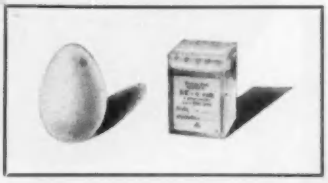

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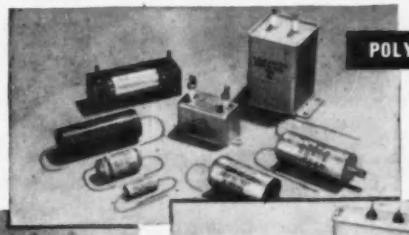

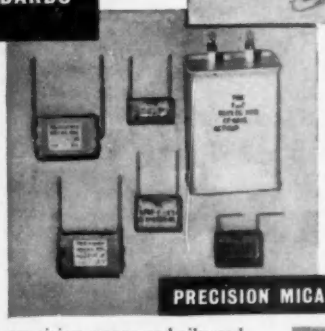

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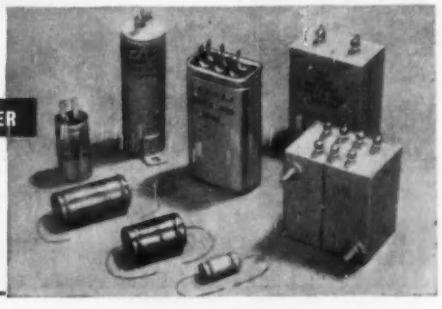

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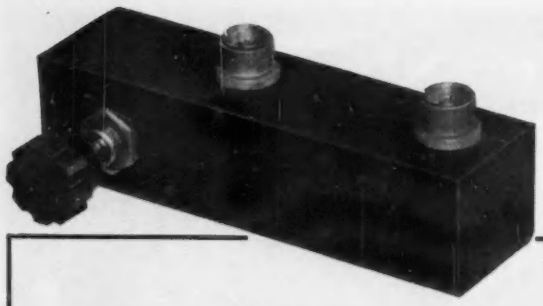

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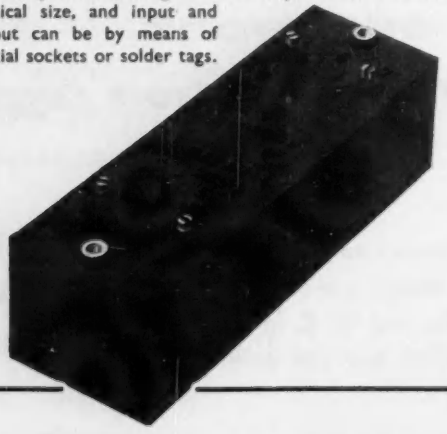

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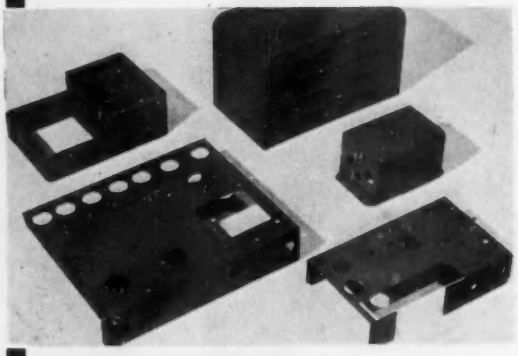

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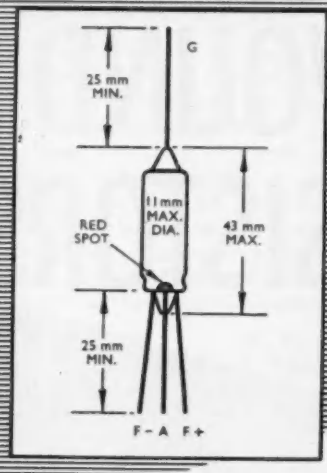

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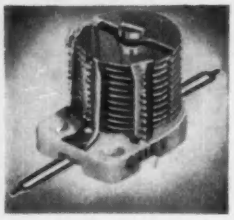

Illustration (approx.) actual size

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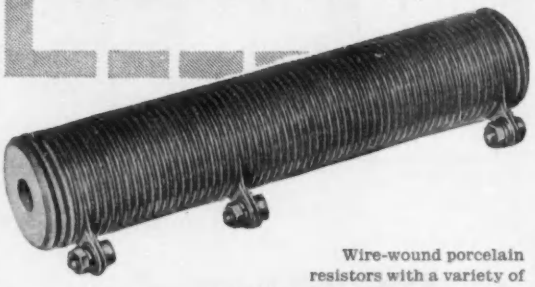

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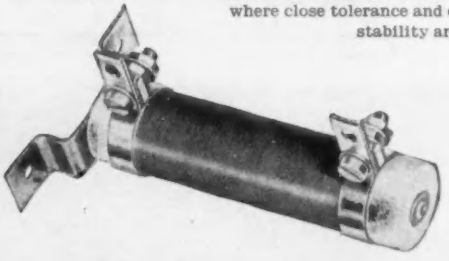

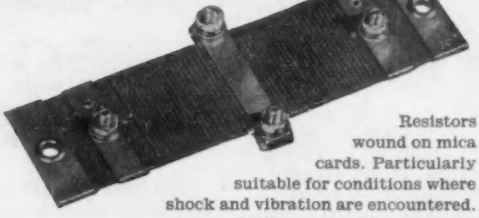

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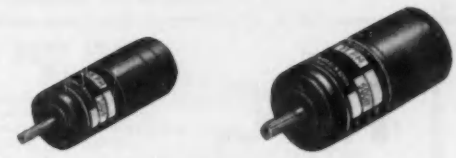

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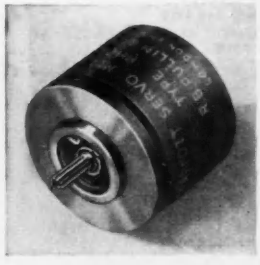

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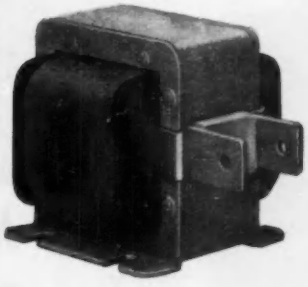

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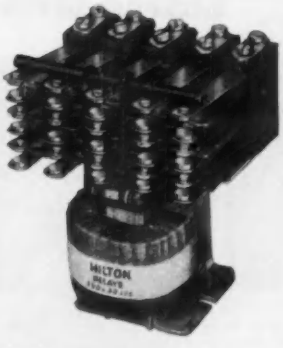

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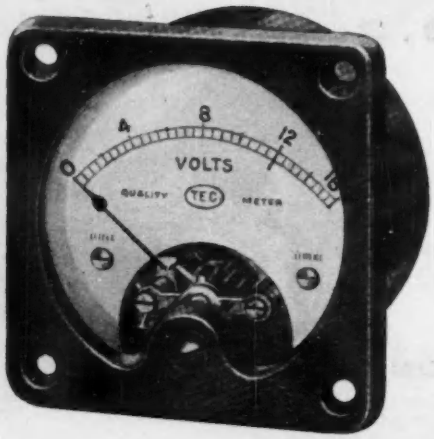

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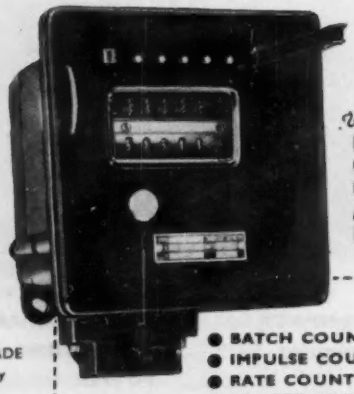

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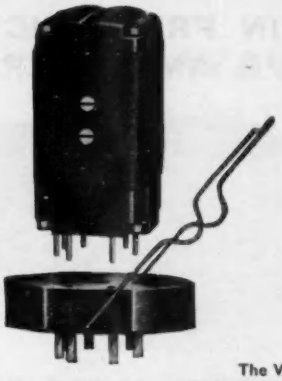

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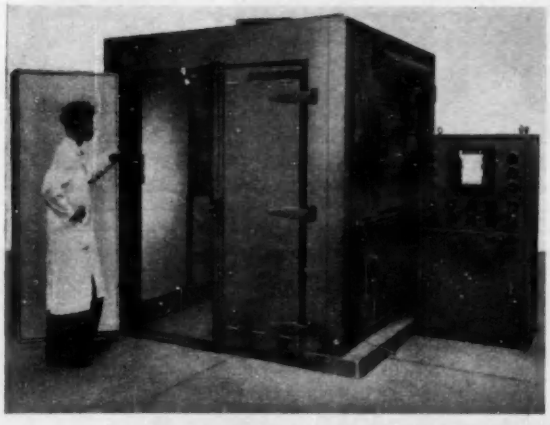

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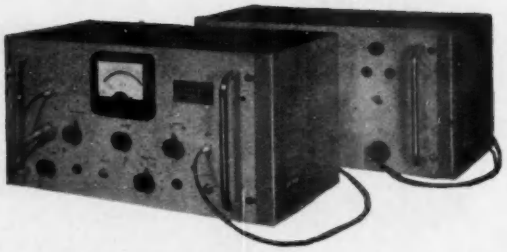

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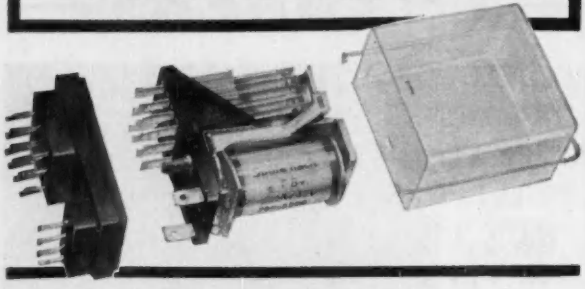

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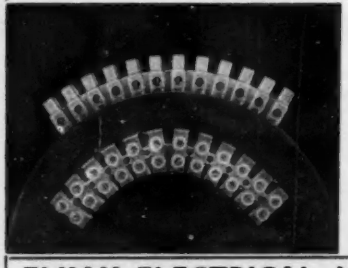

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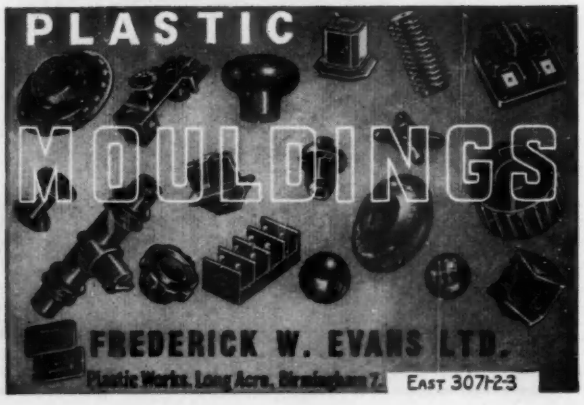

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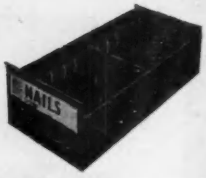

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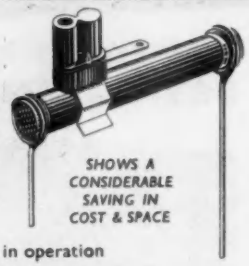

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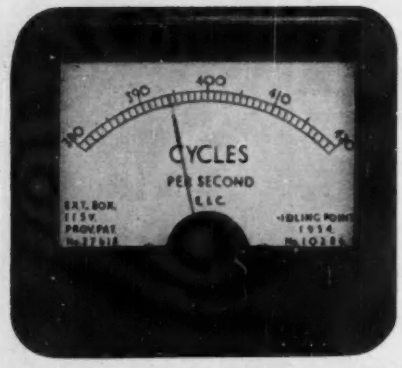

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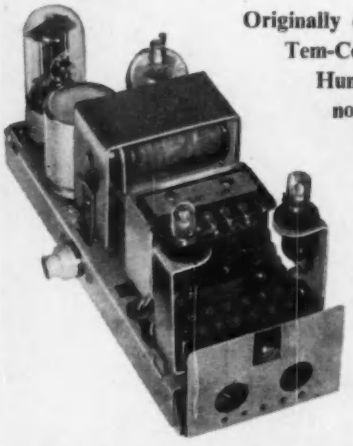

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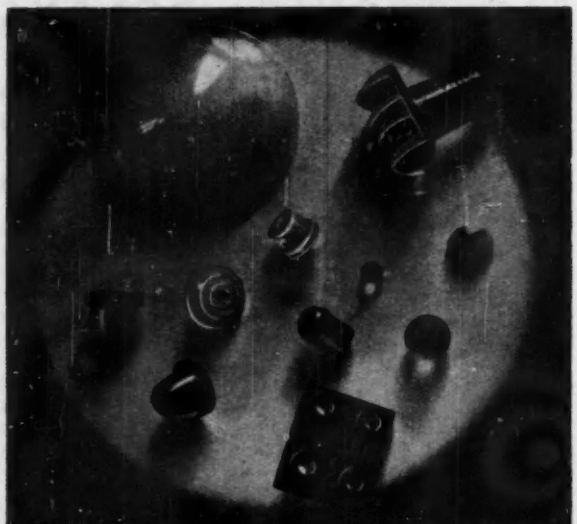

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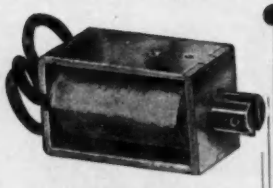

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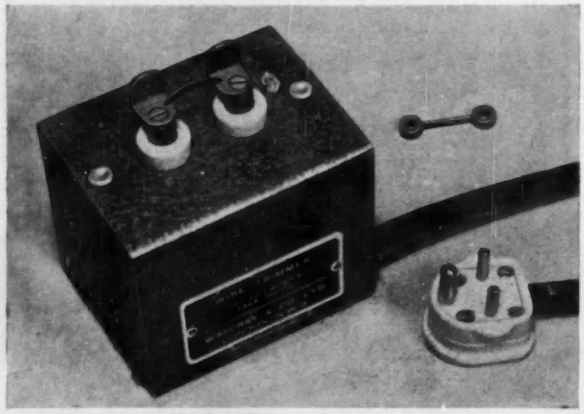

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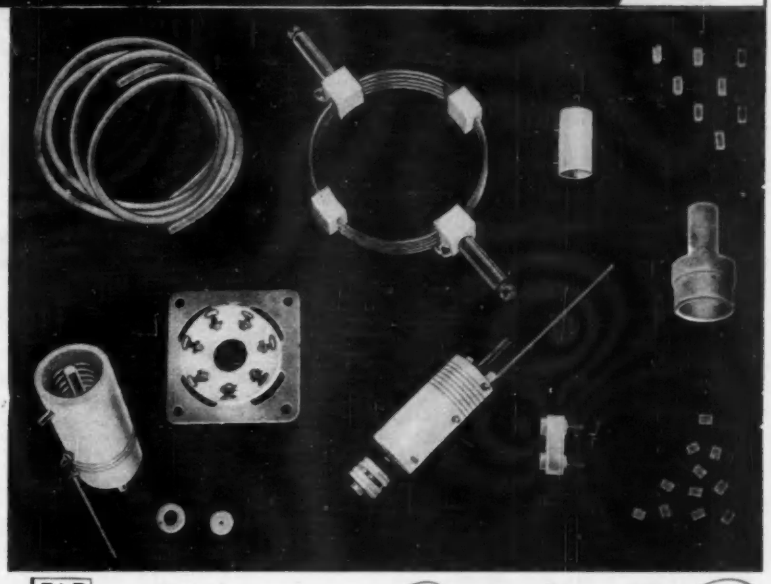

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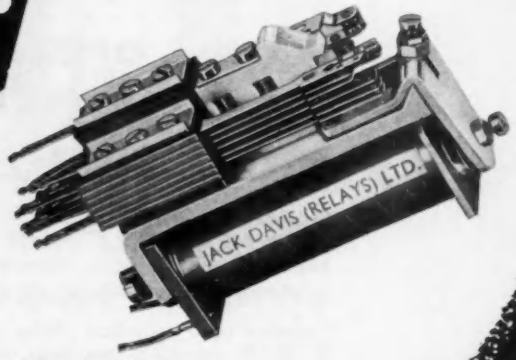

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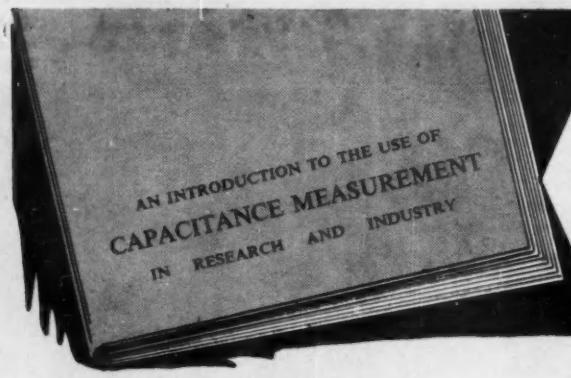

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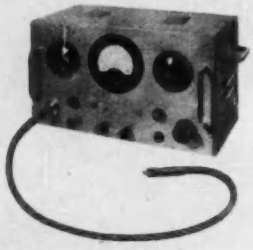

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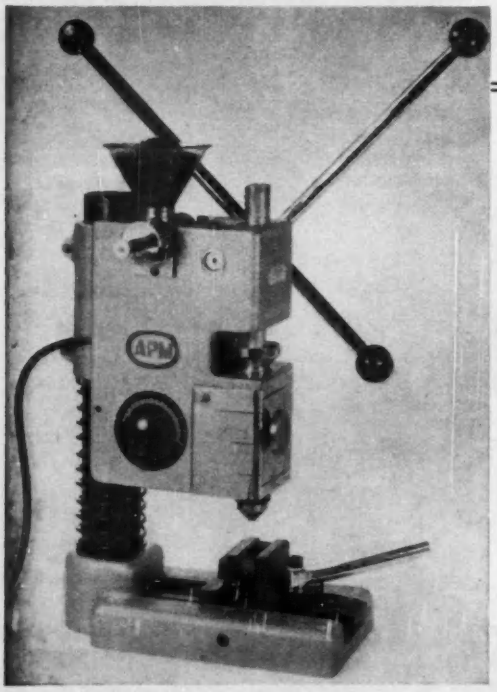

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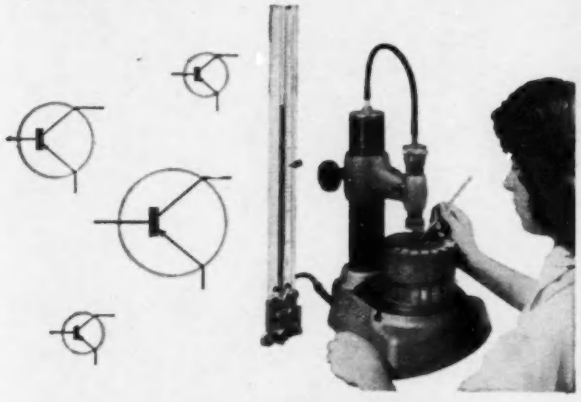
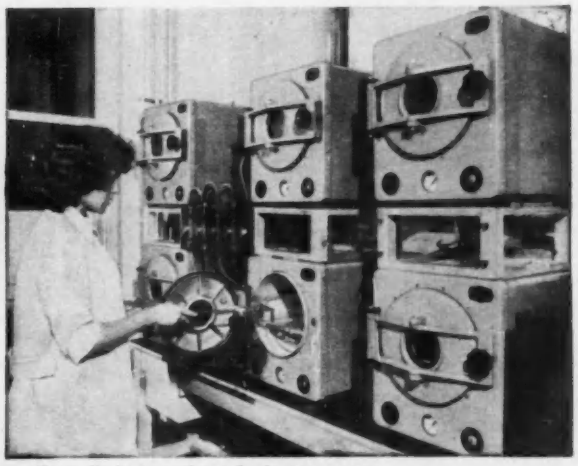


transistor manufacture

In the manufacture of transistors, Siemens Edison Swan Limited use a Birlec direct dehumidifier to maintain dry, dust-free conditions for the preparation and final assembly of germanium wafers. Maintaining 10% relative humidity conditions, the direct dehumidifier ensures accurate grading of the wafers according to thickness, and perfect electrical contact between the wafers forming emitter, base, and collector in the transistor.



Above : Drying germanium wafers in vacuum ovens
Left : Grading germanium wafers prior to assembling into transistors

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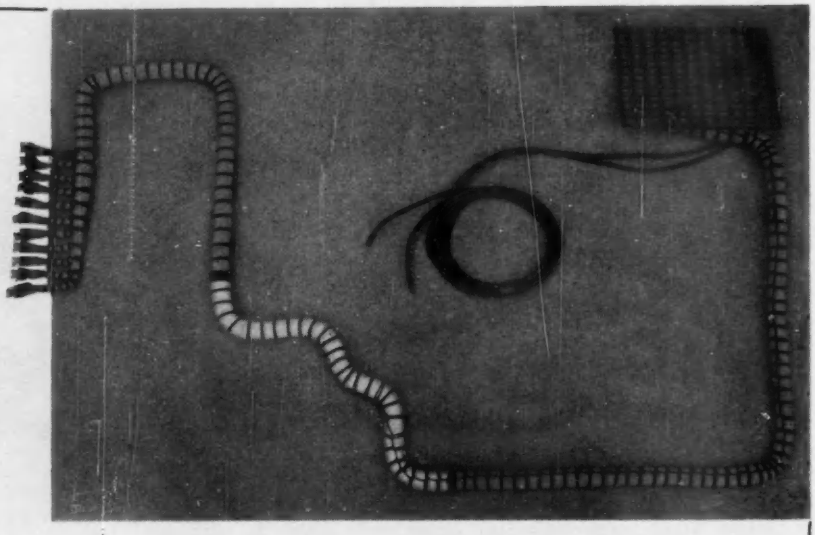

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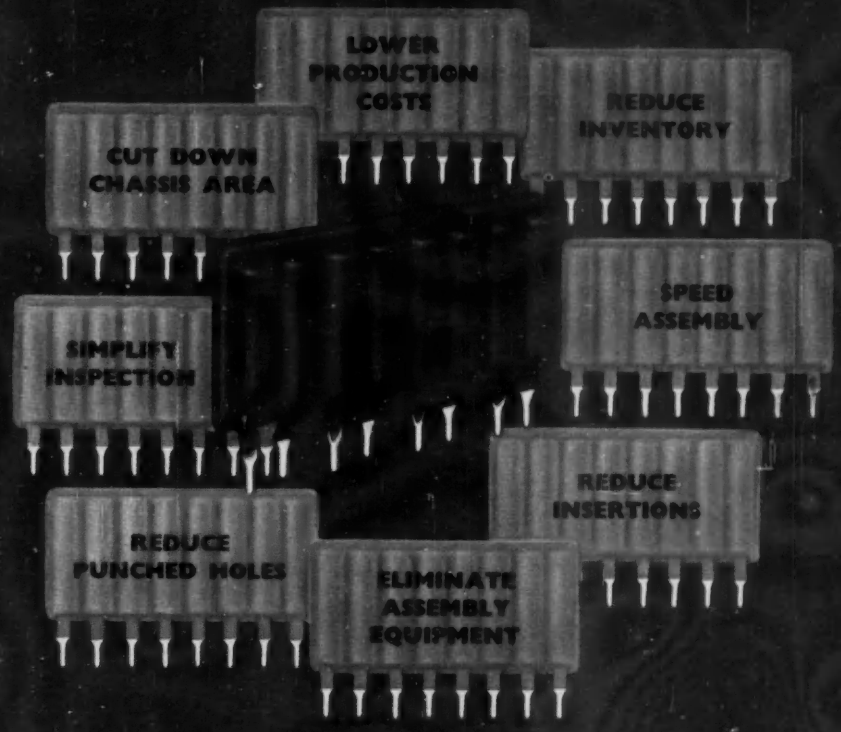

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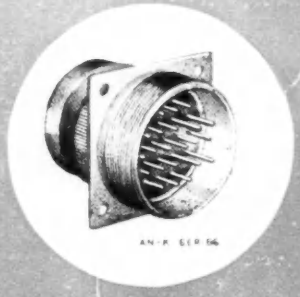

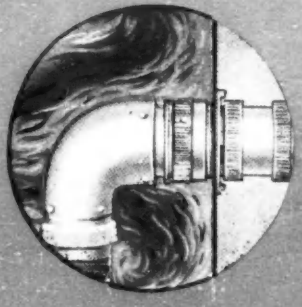

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